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ZOONOTIC DISEASES: EPIDEMIOLOGY, TRANSMISSION, AND CONTROL STRATEGIES



EDITORS

Dr. M. K. Vijaya LAKSHMI

Dr. Özgür ÇELEBİ

Puniparthi SUNITHA

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EDITORS

Dr. M. K. Vijaya LAKSHMI

Dr. Özgür ÇELEBİ
ORCID ID: 0000-0003-4578-9474

Puniparthi SUNITHA
ORCID ID: 0009-0006-0930-4520

AUTHORS

Assist. Prof. Dr. M. PAZHANISAMY¹

Dr. M. K. Vijaya LAKSHMI ²

Dr. Mahmut UÇAR³

Dr. Danish RIAZ⁴

Dr. Fayyaz RASOOL⁵

Dr. Mati ULLAH⁶

Dr. Syed Makhdoom HUSSAIN⁷

Dr. Javed Ahmad UJAN⁸

Dr. Khadim Hussain MEMON⁹

Dr. Waheed Ali PANHWAR¹⁰

Dr. Awais MAQSOOD¹¹

Pooja RASAL¹²

Gaurav KASAR¹³

Pranoti NIKAM¹⁴

Akanksha PUNEKAR¹⁵

Madhuri NAGARE¹⁶

Muhammad Taufiq ABADI¹⁷

G. GUNASEKAR¹⁸

Puniparthi SUNITHA¹⁹

Muhammad YOUSIF²⁰

Rahmi AGUSTINA²¹

Amusan Elizabeth TOLUWANI²²

Anifowoshe Isaac OLAOLUWA²³

Oladeji Deborah DARA²⁴

²Faculty of Pharmacy, India

¹Department of Entomology, Agriculture College and Research
Institute, TNAU, Kudumiyamalai, Tamil Nadu, India.

³Yakutiye Municipality,
ORCID ID: 0000-0003-2740-6476

⁴University of Education, Department of Zoology, Division of Science
and technology, Lahore Pakistan

⁵University of Education, Department of Zoology, Division of Science
and technology, Lahore Pakistan

⁶University of Education, Department of Zoology, Division of Science
and technology, Lahore Pakistan

⁷Government College University, Department of Zoology, Faisalabad
Pakistan

⁸Shah Abdul Latif University, Department of Zoology, Khairpur
Pakistan

⁹Shah Abdul Latif University Department of Zoology, Khairpur
Pakistan

¹⁰University of Sindh, Department of Zoology, Jamshoro, Hyderabad,
Pakistan

¹¹Government College University, Department of Bioinformatics and
Biotechnology, Faisalabad Pakistan

¹²JES's SND College of Pharmacy, Babhulgaon, Dist. Nashik, India

¹³Divine College of Pharmacy, Satana, Dist. Nashik, India

¹⁴JES's SND College of Pharmacy, Babhulgaon, Dist. Nashik, India

¹⁵JES's SND College of Pharmacy, Babhulgaon, Dist. Nashik, India

¹⁶JES's SND College of Pharmacy, Babhulgaon, Dist. Nashik, India

¹⁷Indonesia

¹⁸Tamil Nadu Agricultural University, Ph. D Scholar, Department of
Agricultural Entomology, Coimbatore, Tamil Nadu, India.

¹⁹Bharath Institute of Higher Education and Research Faculty of
Pharmacy, Selaipur, Chennai, Tamilnadu

²⁰University of Education, Department of Zoology, Division of Science
and technology, Lahore Pakistan

²¹Biology in Universitas Jabal Ghafur Sigli Aceh, Indonesia

²²Ajayi Crowther University, Department of Crop and Animal Science,
Faculty of Agriculture, P.M.B. 1066, Oyo, Oyo State, Nigeria

²³Ajayi Crowther University Department of Crop and Animal Science,
Faculty of Agriculture, P.M.B. 1066, Oyo, Oyo State, Nigeria

²⁴Department of Agricultural Production Technology, Moor Plantation,
Ibadan, Oyo State, Nigeria

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PREFACE

The emergence and spread of zoonotic diseases have long posed profound challenges to global public health, environmental stability, and socioeconomic structures. In recent decades, the increasing interconnection of human, animal, and ecological systems has heightened the need for comprehensive academic studies that address the multifaceted nature of these diseases. This book, *Zoonotic Diseases: Epidemiology, Transmission, And Control Strategies*, represents an invaluable contribution to this urgent area of scientific inquiry, offering critical insights into disease transmission dynamics, preventive strategies, and policy implications.

We extend our sincere gratitude to all the contributors whose dedication and scholarly expertise have shaped the richness of this work. Special appreciation is directed to UBAK Publishing House for its unwavering support, to its General Coordinator, Assoc. Prof. Dr. Ethem İlhan Şahin, for his visionary leadership, and to Research Assistant Merve Küçük, whose valuable contributions have greatly facilitated the completion of this scholarly endeavor.

It is our hope that this book will serve as a vital resource for researchers, educators, and practitioners, inspiring future studies and fostering collaborative efforts in the global fight against zoonotic diseases.

Editors

Dr. M. K. Vijaya LAKSHMI

Dr. Özgür ÇELEBİ

Puniparthi SUNITHA

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Dr. Danish RIAZ

Muhammad YOUSIF

Dr. Fayyaz RASOOL

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**ZOONOTIC DISEASES: EPIDEMIOLOGY, TRANSMISSION, AND
CONTROL STRATEGIES**

CHAPTER 1
**ZOONOTIC DISEASES: A COMPREHENSIVE
REVIEW OF TOXOPLASMOSIS AND ITS IMPACT
ON PUBLIC HEALTH**

¹ Pooja RASAL

² Gaurav KASAR

¹Pranoti NIKAM

¹Akanksha PUNEKAR

¹Madhuri NAGARE

¹ JES's SND College of Pharmacy, Babhulgaon, Dist. Nashik, India

² Divine College of Pharmacy, Satana, Dist. Nashik, India

ZOONOTIC DISEASES: EPIDEMIOLOGY, TRANSMISSION, AND CONTROL STRATEGIES

INTRODUCTION

Zoonotic diseases, also known as zoonoses, are infectious diseases that are transmitted between animals and humans. These diseases are caused by a variety of pathogens, including bacteria, viruses, parasites, and fungi, which can be transmitted directly or indirectly from animals to humans. Zoonoses represent a significant threat to global public health as they account for more than 60% of all human infectious diseases, with over 70% of emerging infectious diseases having an animal origin (1). Examples of zoonotic diseases include rabies, avian influenza, Ebola, and Toxoplasmosis. Zoonoses not only pose direct health risks but also contribute to economic burdens on health systems and agricultural sectors due to their impact on livestock and wildlife populations (2). Their transmission is influenced by environmental factors, human behavior, and the close interactions between humans and animals, particularly in urbanization, global trade, and climate change (3).

Toxoplasmosis, caused by the protozoan *Toxoplasma gondii*, is one of the most common zoonotic infections worldwide, with significant public health implications. This disease is typically associated with domestic cats, which are the definitive hosts of the parasite, but humans and other animals can also serve as intermediate hosts. The significance of Toxoplasmosis lies in its ability to cause a wide spectrum of clinical manifestations, ranging from asymptomatic infections to severe outcomes such as encephalitis, ocular toxoplasmosis, and congenital toxoplasmosis, which can lead to neurological and developmental issues in newborns (4). It is a particularly serious concern for immunocompromised individuals, such as those with HIV/AIDS or organ transplant recipients, who are at increased risk for developing more severe forms of the disease (5). Furthermore, the potential for congenital transmission during pregnancy highlights the importance of early detection and management of the disease in pregnant women, as it can result in miscarriage, stillbirth, or lifelong disabilities in the child (6).

Toxoplasmosis has a global distribution, with prevalence rates varying depending on geographic location, socio-economic conditions, and cultural practices. Studies suggest that approximately one-third of the global population has been exposed to *Toxoplasma gondii* at some point in their lives (7). The disease is more common in areas where foodborne transmission is prevalent,

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such as regions where undercooked meat is a part of the diet, or where there is poor sanitation and close contact with animals, particularly cats (8). For example, the prevalence of *T. gondii* antibodies is higher in countries in Latin America, Eastern Europe, and parts of Africa, while lower in parts of Asia and Scandinavia (9). In the United States, it is estimated that around 11% of the population is infected, but most cases are asymptomatic or mild (10). The distribution of the disease can be influenced by multiple factors, including the presence of domestic cats, agricultural practices, and food safety standards (11). Additionally, the disease has a substantial impact on public health due to its chronic nature and the associated healthcare costs related to treating severe cases, especially in immunocompromised individuals and pregnant women (12).

1. MICROORGANISM OVERVIEW: DESCRIPTION OF TOXOPLASMA GONDII, ITS TAXONOMY, MORPHOLOGY, AND LIFE CYCLE

Toxoplasma gondii is an obligate intracellular protozoan parasite that belongs to the phylum Apicomplexa and the family Sarcosporidiidae. It is the causative agent of toxoplasmosis, a widespread zoonotic disease affecting a variety of warm-blooded animals, including humans. The organism was first described in 1908 by Nicolle and Manceaux in Tunisia, and its taxonomy has evolved since then, with *T. gondii* classified within the genus *Toxoplasma*. The parasite exists in several morphological forms during its life cycle, including oocysts, tachyzoites, bradyzoites, and sporozoites.

- **Oocysts:** The environmental form, shed in the feces of infected definitive hosts (e.g., domestic cats), which are highly resilient and can survive in the environment for extended periods.
- **Tachyzoites:** The rapidly dividing form, responsible for the acute phase of infection, that disseminates throughout the host's body.
- **Bradyzoites:** The slowly replicating form that forms cysts in tissues, including the brain, muscles, and eyes, contributing to the chronic phase of infection.

The life cycle of *T. gondii* involves both definitive and intermediate hosts, with domestic cats (and other Felidae) being the definitive hosts, where

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sexual reproduction of the parasite occurs. Intermediate hosts can include humans, other mammals, and birds, where the parasite undergoes asexual reproduction.

2. INFECTION CYCLE: EXPLANATION OF THE BIOLOGICAL CYCLE (DEFINITIVE HOST, INTERMEDIATE HOSTS, OOCYST FORMATION)

The life cycle of *T. gondii* consists of sexual and asexual phases that occur in different hosts. The cycle begins when an infected cat sheds oocysts in its feces into the environment. These oocysts, which contain sporozoites, become infectious after 1–5 days in the environment. Intermediate hosts, including humans, become infected by ingesting oocysts from contaminated food, water, soil, or direct contact with infected cat feces. Upon ingestion, oocysts release sporozoites, which invade intestinal cells and differentiate into tachyzoites.

- **Definitive Host (Cat):** In the cat's intestine, tachyzoites differentiate into gametocytes (male and female forms), which undergo fertilization, forming oocysts. These oocysts are then excreted in the cat's feces.
- **Intermediate Hosts (Humans and Other Animals):** In intermediate hosts, the tachyzoites rapidly proliferate and disseminate through the bloodstream, invading various tissues, including the brain, heart, and muscles. Over time, some tachyzoites convert into bradyzoites, forming tissue cysts that can persist for the lifetime of the host.

This cycle of infection and reproduction is central to the spread of *T. gondii* among both definitive and intermediate hosts. Transmission from intermediate hosts to definitive hosts occurs when a cat consumes infected prey, completing the cycle.

3. GENETIC VARIABILITY: VARIANTS OF T. GONDII AND THEIR IMPACT ON VIRULENCE AND TRANSMISSION

Toxoplasma gondii exhibits significant genetic diversity, with three primary clonal lineages identified: Types I, II, and III. These lineages are characterized by differences in virulence, transmission, and host adaptability.

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- **Type I:** This lineage is associated with high virulence and is typically isolated from severe cases of toxoplasmosis, particularly in immunocompromised individuals. Type I strains replicate rapidly and are often associated with the acute phase of infection.
- **Type II:** This is the most common lineage found in human infections and is generally considered less virulent. However, it is the predominant strain in both animals and humans worldwide, contributing significantly to the chronic stages of the infection.
- **Type III:** Although less virulent than Type I, Type III strains are also frequently isolated from human and animal infections. These strains are often associated with asymptomatic infections.

The genetic variability of *T. gondii* affects its ability to invade host cells, replicate, and persist within host tissues, influencing disease progression and clinical outcomes. Additionally, the variation in virulence can affect the transmission dynamics of the parasite, influencing the incidence of congenital toxoplasmosis and the development of severe cases in immunocompromised individuals. The variability in these strains also affects the design of vaccines and treatment strategies, as different strains may exhibit varying levels of resistance to interventions.

4. TRANSMISSION OF TOXOPLASMOSIS

Toxoplasma gondii is transmitted through several routes, primarily involving animal reservoirs, human contact with infected animals, ingestion of contaminated food, and environmental exposure. The different modes of transmission highlight the complex lifecycle of the parasite and its wide-reaching effects on both animal and human health.

4.1 Animal Reservoirs: Role of Felines (Domestic Cats) as Definitive Hosts, and Other Animals as Intermediate Hosts

Felines, particularly domestic cats, are the definitive hosts of *Toxoplasma gondii*, meaning that sexual reproduction of the parasite occurs in their intestines. When cats ingest infected prey (such as rodents or birds), *T. gondii* undergoes sexual reproduction in the cat's intestines, producing oocysts, which are then shed in the cat's feces (13). These oocysts, once released into

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the environment, can remain viable for months and serve as a source of infection for intermediate hosts, including humans and other mammals (14).

Intermediate hosts, which include a variety of animals like livestock (e.g., sheep, pigs) and rodents, acquire the parasite through ingestion of oocysts from contaminated food, water, or soil (15). In these animals, *T. gondii* forms cysts, predominantly in muscle and brain tissue. These cysts can later be transmitted to humans through the consumption of undercooked meat or by other means (16).

5. HUMAN TRANSMISSION

Humans can become infected with *T. gondii* through several pathways:

- **Consumption of Undercooked Meat (e.g., Pork, Lamb):** One of the most common routes of transmission to humans is through the consumption of undercooked or raw meat from infected animals, particularly pork, lamb, and venison. *Toxoplasma gondii* forms tissue cysts in these animals, and inadequate cooking of the meat can lead to the ingestion of viable cysts (17). This is a significant concern in areas where eating raw or undercooked meat is part of traditional dietary practices (18).
- **Contamination via Oocysts in Cat Feces:** Humans can also become infected by handling contaminated soil, water, or surfaces that have been exposed to cat feces containing oocysts. Activities such as gardening, cleaning a cat's litter box, or consuming unwashed produce grown in contaminated soil can lead to infection. Cats shed oocysts in their feces, which can contaminate the environment for up to several months (19). Direct contact with infected feces is a well-documented source of infection for humans, especially for pregnant women, who are at risk of congenital toxoplasmosis (20).
- **Congenital Transmission (Mother-to-Child):** Pregnant women who become infected with *T. gondii* for the first time during pregnancy may transmit the infection to their unborn child. The parasite can cross the placenta, leading to congenital toxoplasmosis. This can result in severe outcomes such as miscarriage, stillbirth, or neurological damage, including hydrocephalus and retinochoroiditis in newborns (21).

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Congenital infection is particularly concerning because it can cause long-term health issues in children if not diagnosed and treated early (22).

- **Organ Transplantation and Blood Transfusion:** Transmission of *Toxoplasma gondii* can also occur through organ transplantation or blood transfusions. In immunocompromised individuals, particularly those who have received a solid organ transplant, the parasite can cause severe illness, including toxoplasmic encephalitis (23). This route of transmission is relatively rare but significant in certain high-risk populations, such as transplant recipients or patients with HIV/AIDS.

5.1 Environmental Factors: Role of Contaminated Water and Soil in Transmission

Environmental factors, including contaminated water and soil, play a key role in the transmission of *Toxoplasma gondii*. Oocysts excreted by infected cats can contaminate water sources, agricultural soil, and even recreational water bodies. When these oocysts are ingested by humans through contaminated drinking water or during activities like swimming in polluted water, they can cause infection (26). Additionally, oocysts can contaminate soil, where they persist for long periods. Individuals who handle contaminated soil (such as gardeners) or consume contaminated, unwashed fruits and vegetables are at increased risk. In particular, waterborne outbreaks of toxoplasmosis have been reported in various parts of the world, including cases linked to agricultural irrigation water and contaminated public water supplies.

6. CLINICAL MANIFESTATIONS AND SYMPTOMS

6.1 Asymptomatic Infections

A majority of individuals infected with *Toxoplasma gondii* experience asymptomatic infections. In fact, it is estimated that up to 80% of infected individuals show no obvious symptoms (24). These individuals carry the parasite in a latent form, which can persist in the body for long periods, typically within tissues such as the brain and muscles. In healthy individuals with an intact immune system, the parasite remains dormant and does not cause overt clinical illness. However, even in the absence of symptoms, the infection

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can still be detected through serological tests that identify specific antibodies, reflecting past exposure to the parasite (25).

6.2 Acute Symptoms

In cases where the infection progresses to an acute phase, symptoms are often mild and non-specific, resembling a flu-like illness. The most common manifestations include fever, headache, muscle aches, and fatigue. Lymphadenopathy, or the swelling of lymph nodes, is another characteristic feature of acute toxoplasmosis. These symptoms are usually self-limiting and may resolve within weeks without medical intervention (26). The acute phase of the infection is typically more apparent in immunocompetent individuals who are experiencing their first infection, as the immune system mounts a response to the parasite. In contrast, individuals who have been previously exposed to *Toxoplasma* may not exhibit noticeable symptoms during reactivation (27).

6.3 Severe Cases

Severe cases of toxoplasmosis occur primarily in immunocompromised individuals, such as those with HIV/AIDS or transplant recipients. In these individuals, the immune system's ability to control the parasite is compromised, leading to toxoplasmic encephalitis (TE), a life-threatening condition that involves inflammation of the brain (28). Toxoplasmic encephalitis is characterized by symptoms such as seizures, confusion, motor weakness, and altered mental status. It is one of the most common causes of focal brain lesions in patients with HIV/AIDS (29). Another severe complication is ocular toxoplasmosis, which affects the eyes and can lead to vision loss if left untreated. This form of toxoplasmosis presents as retinochoroiditis, causing pain, blurred vision, and eye redness (30). Ocular involvement can occur in both immunocompetent and immunocompromised individuals but is more frequent in those with compromised immune systems (31).

6.4 Congenital Toxoplasmosis

Congenital toxoplasmosis occurs when a pregnant woman acquires the infection for the first time during pregnancy and transmits it to her unborn child

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through the placenta. The clinical outcomes of congenital toxoplasmosis can range from asymptomatic to severe, with newborns presenting with a variety of symptoms. In severe cases, congenital toxoplasmosis can lead to miscarriage, stillbirth, or neurological disorders such as hydrocephalus, microcephaly, and chorioretinitis (32). Newborns infected with the parasite at birth may show signs such as jaundice, fever, and seizures, and long-term complications, including developmental delays and vision problems, may manifest later in life (33). Early diagnosis and treatment are crucial in preventing or mitigating these outcomes, as untreated congenital toxoplasmosis can lead to significant morbidity and mortality in affected infants (34).

7. DIAGNOSIS OF TOXOPLASMOSIS

7.1 Serological Tests: Use of IgM and IgG Antibodies to Detect Acute and Chronic Infections

Serological testing remains the cornerstone for the diagnosis of toxoplasmosis. The detection of specific IgM and IgG antibodies in the patient's blood can help differentiate between acute and chronic infections. The presence of IgM antibodies indicates a recent or acute infection, while IgG antibodies suggest past exposure or chronic infection (35). In individuals with a primary infection, IgM antibodies appear first, typically within one to two weeks after exposure, and can remain detectable for several months. IgG antibodies, on the other hand, appear later but persist for life, indicating prior exposure and immunity (36). These serological markers are useful not only for diagnosing active infections but also for determining whether an individual is at risk of congenital transmission, especially in pregnant women (37).

7.2 PCR and Molecular Diagnostics: Molecular Techniques for Detecting *T. gondii* DNA

Polymerase chain reaction (PCR) is an advanced diagnostic tool used to detect *Toxoplasma gondii* DNA directly from blood, cerebrospinal fluid (CSF), or tissue biopsies (38). PCR is particularly valuable in diagnosing severe cases, such as toxoplasmic encephalitis, and in immunocompromised patients who may not produce a strong antibody response. This molecular technique offers high sensitivity and specificity, enabling the detection of low quantities of the

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parasite's DNA, even during the latent or reactivated phases of infection. Additionally, PCR has been employed in diagnosing congenital toxoplasmosis in neonates by detecting the presence of parasite DNA in amniotic fluid or cord blood (39).

7.3 Other Diagnostic Methods: Imaging (e.g., CT, MRI) in Severe Cases, Histopathological Examination

For patients with severe manifestations, such as toxoplasmic encephalitis, imaging techniques like CT (computed tomography) or MRI (magnetic resonance imaging) are often used. These imaging modalities help identify characteristic brain lesions caused by the infection, including ring-enhancing lesions, which are indicative of toxoplasmic encephalitis (40). Histopathological examination of biopsy samples from affected tissues can also confirm the presence of the parasite. In cases of ocular toxoplasmosis, fundoscopic examination of the retina may reveal characteristic lesions, such as retinochoroiditis, providing further diagnostic insight (41).

8. TREATMENT AND MANAGEMENT

8.1 Antimicrobial Agents: Overview of Commonly Used Drugs such as Pyrimethamine and Sulfadiazine, and Alternative Therapies

The primary treatment for toxoplasmosis involves a combination of pyrimethamine and sulfadiazine, which are both antiparasitic drugs. Pyrimethamine inhibits the enzyme dihydrofolate reductase, interfering with folic acid metabolism in *Toxoplasma gondii*, while sulfadiazine works by inhibiting folic acid synthesis in the parasite (42). This combination is highly effective in treating both acute and severe infections, such as toxoplasmic encephalitis. For individuals who cannot tolerate these medications, alternative treatments may include clindamycin, spiramycin, or atovaquone, which may be used in combination with pyrimethamine (43). Treatment duration typically lasts for several weeks, and for immunocompromised patients, long-term maintenance therapy may be necessary to prevent recurrence (44).

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8.2 Management of Immunocompromised Patients: Special Treatment Protocols for HIV/AIDS and Organ Transplant Recipients

Immunocompromised individuals, particularly those with HIV/AIDS or organ transplant recipients, require special treatment protocols for toxoplasmosis. In these individuals, the infection can be more severe, and toxoplasmic encephalitis may develop as a life-threatening complication. Standard treatment for these patients includes the combination of pyrimethamine and sulfadiazine, along with leucovorin to prevent bone marrow suppression caused by pyrimethamine (45). For HIV/AIDS patients, antiretroviral therapy (ART) is also essential to restore immune function and prevent further episodes of toxoplasmic encephalitis (46). In organ transplant recipients, prophylactic treatment with pyrimethamine and sulfadiazine may be considered to prevent the onset of infection, especially during the early post-transplant period (47).

Congenital Cases: Treatment for Newborns and Pregnant Women

In cases of congenital toxoplasmosis, early diagnosis and treatment are critical to reduce the risk of severe complications in newborns. Spiramycin is often recommended for pregnant women who are infected with *Toxoplasma gondii*, as it has been shown to reduce the likelihood of fetal transmission if administered during the early stages of pregnancy (48). For infected newborns, a combination of pyrimethamine and sulfadiazine is used to treat congenital toxoplasmosis, alongside leucovorin to mitigate the effects of pyrimethamine on bone marrow function (49). Prompt treatment can help reduce the incidence of severe congenital outcomes such as hydrocephalus, retinochoroiditis, and developmental delay (50).

Prevention and Control: Strategies for Reducing Transmission

Preventive measures are crucial in reducing the transmission of *Toxoplasma gondii*. Basic hygiene practices, such as washing hands thoroughly after handling raw meat, gardening, or cleaning a cat's litter box, are essential in preventing infection (51). Additionally, cooking meat thoroughly to safe

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temperatures (e.g., 160°F or 71°C) can help kill tissue cysts and reduce the risk of infection (52). Pregnant women and immunocompromised individuals should avoid handling cat litter or cleaning cat feces to minimize the risk of exposure to oocysts (53). Control measures in domestic animals, such as reducing the number of stray cats and limiting their access to outdoor environments, may also help prevent the spread of *Toxoplasma* through the shedding of oocysts in feces (54). Public health interventions focusing on hygiene, food safety, and environmental management can significantly reduce the incidence of toxoplasmosis in both humans and animals.

CONCLUSION

Toxoplasmosis, caused by the protozoan *Toxoplasma gondii*, is a widespread zoonotic infection with significant public health implications. While the majority of infections are asymptomatic, the disease can lead to severe complications in immunocompromised individuals, such as those with HIV/AIDS or organ transplant recipients, and can cause congenital abnormalities if transmitted during pregnancy. Early diagnosis through serological tests, PCR, and imaging techniques is crucial, particularly in high-risk populations. Treatment primarily involves the combination of antiparasitic drugs, including pyrimethamine and sulfadiazine, while special management protocols are necessary for immunocompromised patients and pregnant women. Preventive measures, including proper food handling, hygiene practices, and animal control, play a key role in reducing transmission rates. Continued research into the epidemiology, pathogenesis, and treatment strategies of toxoplasmosis is essential to improve prevention and management efforts globally.

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CHAPTER 2
FINANCIAL MANAGEMENT STRATEGIES FOR
BUSINESSES AFFECTED BY ZOONOTIC DISEASE
OUTBREAKS

Muhammad Taufiq ABADI¹

¹Indonesia

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INTRODUCTION

The emergence of zoonotic diseases—pathogens transmitted from animals to humans—has become a significant threat to global health and economic stability. Recent outbreaks, such as COVID-19, Ebola, and avian influenza, have demonstrated the far-reaching consequences of these diseases on businesses across industries (Jones et al., 2020). The economic impact of zoonotic disease outbreaks is multifaceted, affecting supply chains, consumer behavior, and operational continuity. In this context, financial management emerges as a critical tool for businesses to navigate the uncertainties and challenges posed by such crises.

Financial management during zoonotic disease outbreaks requires a proactive and adaptive approach. Traditional financial strategies may prove inadequate in the face of sudden revenue declines, increased operational costs, and supply chain disruptions (Smith & Johnson, 2021). Businesses must prioritize liquidity management to ensure short-term survival while also investing in long-term resilience. This chapter aims to provide a comprehensive framework for financial management strategies tailored to businesses affected by zoonotic disease outbreaks.

The chapter is structured as follows: First, it examines the financial challenges posed by zoonotic disease outbreaks, including cash flow volatility and increased operational costs. Second, it explores strategic responses, such as cost optimization, diversification of revenue streams, and investment in digital transformation. Third, it discusses the role of government policies and international collaboration in supporting businesses during such crises. Finally, the chapter concludes with practical recommendations for businesses to enhance their financial resilience in the face of future zoonotic disease outbreaks.

The analysis presented in this chapter is grounded in empirical evidence from recent global crises and draws on insights from reputable international journals. By synthesizing theoretical frameworks and practical case studies, this chapter aims to contribute to the growing body of knowledge on financial management in times of crisis.

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1. FINANCIAL CHALLENGES POSED BY ZOONOTIC DISEASE OUTBREAKS

Zoonotic disease outbreaks create a complex and unpredictable financial environment for businesses. The sudden and widespread nature of these crises often leads to significant disruptions in economic activities, forcing businesses to confront a range of financial challenges. This section examines three key financial challenges: cash flow volatility, supply chain disruptions, and increased operational costs.

Cash Flow Volatility

One of the most immediate financial challenges during a zoonotic disease outbreak is cash flow volatility. Businesses often experience a sharp decline in revenue due to reduced consumer demand, lockdowns, and restrictions on movement (Taufiq, 2024). For example, during the COVID-19 pandemic, many retail and hospitality businesses saw their revenues drop by more than 50% within weeks of the outbreak (Baker et al., 2020). This sudden loss of income creates liquidity crises, making it difficult for businesses to meet their short-term financial obligations, such as payroll, rent, and loan repayments.

Cash flow volatility is further exacerbated by delayed payments from customers and clients. During crises, businesses often extend payment terms to retain customers, which strains their working capital (Gourinchas et al., 2020). Small and medium-sized enterprises (SMEs) are particularly vulnerable to cash flow challenges, as they typically have limited access to external financing and smaller cash reserves (OECD, 2021). Without adequate liquidity management, many businesses risk insolvency during zoonotic disease outbreaks.

Supply Chain Disruptions

Zoonotic disease outbreaks often disrupt global supply chains, creating significant financial challenges for businesses. Lockdowns, travel restrictions, and workforce shortages can halt production and delay the delivery of goods and services (Ivanov, 2021). For instance, during the COVID-19 pandemic, manufacturers faced shortages of critical components, leading to production stoppages and revenue losses (Shih, 2020). These disruptions not only increase

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costs but also reduce the ability of businesses to fulfill customer orders, damaging their reputation and market share.

Supply chain disruptions also lead to increased inventory holding costs. Businesses may stockpile raw materials or finished goods to mitigate the risk of future shortages, tying up capital that could be used for other purposes (Chowdhury et al., 2021). Additionally, businesses may incur higher transportation costs due to reduced availability of shipping options and increased demand for logistics services. These factors collectively strain financial resources and reduce profitability.

Increased Operational Costs

Zoonotic disease outbreaks often result in higher operational costs for businesses. Health and safety measures, such as personal protective equipment (PPE), sanitization, and social distancing protocols, require significant investment (World Health Organization, 2020). For example, during the COVID-19 pandemic, businesses in the hospitality and healthcare sectors reported a 20-30% increase in operational costs due to these measures (McKinsey & Company, 2021).

Additionally, businesses may face higher labor costs due to absenteeism, overtime payments, and the need to hire temporary workers. Workforce shortages caused by illness or quarantine measures can further increase labor costs and reduce productivity (ILO, 2020). These increased operational costs, combined with reduced revenue, create a challenging financial environment for businesses, particularly those with thin profit margins.

2. STRATEGIC FINANCIAL RESPONSES TO ZOONOTIC DISEASE OUTBREAKS

In the face of zoonotic disease outbreaks, businesses must adopt proactive and adaptive financial strategies to ensure survival and build long-term resilience. This section explores four key strategic responses: liquidity management, cost optimization, diversification of revenue streams, and investment in digital transformation. These strategies are supported by empirical evidence and case studies from recent global crises, offering practical insights for businesses navigating financial uncertainties.

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Liquidity Management

Effective liquidity management is critical for businesses to survive the immediate financial shocks caused by zoonotic disease outbreaks. Liquidity, or the availability of cash and cash-equivalent assets, enables businesses to meet short-term obligations and maintain operations during periods of reduced revenue (Taufiq, 2024). During the COVID-19 pandemic, businesses with strong liquidity positions were better equipped to weather the crisis compared to those with limited cash reserves (Campello et al., 2020).

One approach to liquidity management is maintaining a cash buffer or emergency fund. Businesses should aim to hold sufficient cash reserves to cover at least three to six months of operating expenses (OECD, 2021). Additionally, businesses can negotiate extended payment terms with suppliers and creditors to preserve cash flow. For example, many companies successfully renegotiated payment schedules during the COVID-19 pandemic, allowing them to allocate resources more effectively (Gourinchas et al., 2020).

Another strategy is accessing external financing options, such as lines of credit, government loans, or emergency grants. Governments and financial institutions often introduce relief programs during crises to support businesses. For instance, the U.S. Paycheck Protection Program (PPP) provided low-interest loans to small businesses affected by COVID-19, helping them maintain payroll and cover operational costs (Granja et al., 2020). Businesses should actively monitor and leverage such programs to enhance liquidity.

Cost Optimization

Cost optimization is essential for businesses to reduce financial strain and improve profitability during zoonotic disease outbreaks. This involves identifying and eliminating non-essential expenses while maintaining core operations. For example, businesses can renegotiate contracts with suppliers, reduce discretionary spending, and implement energy-saving measures to lower operational costs (McKinsey & Company, 2021).

Workforce management is another critical aspect of cost optimization. Businesses can adopt flexible work arrangements, such as remote work or reduced hours, to lower labor costs without resorting to layoffs (ILO, 2020). Additionally, businesses can invest in automation and technology to streamline

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processes and reduce reliance on manual labor. For instance, during the COVID-19 pandemic, many manufacturing companies accelerated the adoption of robotics to maintain production while minimizing human contact (World Economic Forum, 2021).

Diversification of Revenue Streams

Diversifying revenue streams can help businesses reduce their dependence on a single source of income, making them more resilient to disruptions caused by zoonotic disease outbreaks. For example, during the COVID-19 pandemic, many restaurants shifted to online delivery services to compensate for the loss of dine-in customers (Bartik et al., 2020). Similarly, retailers expanded their e-commerce capabilities to reach customers who were unable or unwilling to visit physical stores (Brynjolfsson et al., 2020).

Businesses can also explore new markets or product lines to generate additional revenue. For instance, some fashion companies repurposed their production facilities to manufacture personal protective equipment (PPE) during the COVID-19 pandemic, creating a new revenue stream while addressing public health needs (Shih, 2020). Diversification requires careful planning and investment but can significantly enhance financial resilience in the long term.

Investment in Digital Transformation

The COVID-19 pandemic highlighted the importance of digital transformation in ensuring business continuity during crises. Businesses that had already invested in digital technologies, such as cloud computing, e-commerce platforms, and remote collaboration tools, were better positioned to adapt to the challenges posed by the pandemic (Bughin et al., 2020). Digital transformation enables businesses to maintain operations, serve customers, and manage supply chains more effectively, even in the face of disruptions.

For example, cloud-based enterprise resource planning (ERP) systems allow businesses to monitor inventory, manage finances, and coordinate supply chains in real time, reducing the impact of disruptions (Ivanov, 2021). Similarly, e-commerce platforms enable businesses to reach customers directly, bypassing traditional distribution channels that may be affected by lockdowns or

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restrictions (Brynjolfsson et al., 2020). Investing in digital transformation not only enhances resilience during crises but also positions businesses for long-term growth in an increasingly digital economy.

3. THE ROLE OF GOVERNMENT POLICIES AND INTERNATIONAL COLLABORATION

Zoonotic disease outbreaks, such as COVID-19, Ebola, and avian influenza, have underscored the importance of coordinated government policies and international collaboration in mitigating their economic and financial impact. Governments and international organizations play a critical role in providing financial relief, stabilizing economies, and fostering resilience among businesses. This section examines the key measures adopted by governments and the role of international collaboration in supporting businesses during zoonotic disease outbreaks.

Government Financial Relief Programs

During zoonotic disease outbreaks, governments often implement financial relief programs to support businesses and prevent economic collapse. These programs typically include direct financial assistance, tax relief, and loan guarantees. For example, during the COVID-19 pandemic, many governments introduced stimulus packages to help businesses retain employees and maintain operations (OECD, 2021). The U.S. Paycheck Protection Program (PPP), for instance, provided low-interest loans to small businesses, with provisions for loan forgiveness if funds were used for payroll and other eligible expenses (Granja et al., 2020).

Tax relief measures, such as deferred tax payments and reduced tax rates, can also alleviate financial pressure on businesses. For example, several European countries allowed businesses to defer value-added tax (VAT) payments during the COVID-19 pandemic, providing them with additional liquidity to manage short-term obligations (IMF, 2020). These measures are particularly beneficial for small and medium-sized enterprises (SMEs), which often lack the financial resilience to withstand prolonged disruptions.

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Stabilization of Financial Markets

Zoonotic disease outbreaks can trigger volatility in financial markets, leading to reduced access to credit and increased borrowing costs for businesses. Governments and central banks play a crucial role in stabilizing financial markets through monetary policy interventions. For instance, during the COVID-19 pandemic, central banks in many countries lowered interest rates and implemented quantitative easing programs to ensure liquidity in financial systems (BIS, 2020). These measures helped businesses access credit at affordable rates, supporting their recovery efforts.

In addition to monetary policy, governments can establish credit guarantee schemes to encourage lending to businesses. For example, the UK's Coronavirus Business Interruption Loan Scheme (CBILS) provided government-backed guarantees to lenders, enabling them to extend credit to businesses affected by the pandemic (British Business Bank, 2020). Such initiatives reduce the risk for financial institutions and increase the availability of credit for businesses in need.

Support for Supply Chain Resilience

Zoonotic disease outbreaks often disrupt global supply chains, creating challenges for businesses that rely on international trade. Governments can support supply chain resilience by providing incentives for local production and diversification of supply sources. For example, during the COVID-19 pandemic, several countries introduced subsidies and tax incentives for domestic manufacturers of critical goods, such as medical supplies and pharmaceuticals (Shih, 2020). These measures reduce dependence on foreign suppliers and enhance the resilience of domestic supply chains.

International collaboration is also essential for addressing supply chain disruptions. Organizations such as the World Trade Organization (WTO) and the World Health Organization (WHO) can facilitate coordination among countries to ensure the uninterrupted flow of essential goods. For instance, the WTO established a task force during the COVID-19 pandemic to monitor trade restrictions and promote transparency in trade policies (WTO, 2020). Such efforts help mitigate the impact of supply chain disruptions on businesses and ensure access to critical resources.

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International Collaboration and Knowledge Sharing

Zoonotic disease outbreaks are global challenges that require coordinated international responses. International organizations, such as the United Nations (UN) and the World Bank, play a vital role in facilitating collaboration and knowledge sharing among countries. For example, the World Bank established the COVID-19 Strategic Preparedness and Response Program (SPRP) to provide financial and technical assistance to countries affected by the pandemic (World Bank, 2020). This program supported healthcare systems, social safety nets, and economic recovery efforts, benefiting businesses and communities worldwide.

Knowledge sharing is another critical aspect of international collaboration. Platforms such as the WHO's Global Outbreak Alert and Response Network (GOARN) enable countries to share information and best practices for managing zoonotic disease outbreaks (WHO, 2020). By learning from the experiences of other countries, governments and businesses can develop more effective strategies for mitigating the impact of future outbreaks.

4. PRACTICAL RECOMMENDATIONS FOR BUSINESSES

The financial challenges posed by zoonotic disease outbreaks require businesses to adopt proactive and adaptive strategies to ensure survival and build long-term resilience. Drawing on the lessons learned from recent global crises, this section provides practical recommendations for businesses to enhance their financial management practices and mitigate the impact of future zoonotic disease outbreaks.

Build and Maintain Cash Reserves

One of the most critical steps businesses can take to prepare for zoonotic disease outbreaks is building and maintaining adequate cash reserves. A cash buffer provides a financial cushion to cover short-term obligations and operational expenses during periods of reduced revenue (Taufiq, 2024). Businesses should aim to hold cash reserves equivalent to at least three to six months of operating expenses (OECD, 2021). This can be achieved by prioritizing liquidity management, reducing discretionary spending, and reinvesting profits into cash reserves.

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Develop a Crisis Management Plan

A well-defined crisis management plan is essential for businesses to respond effectively to zoonotic disease outbreaks. This plan should outline specific actions to be taken during a crisis, such as cost-cutting measures, workforce management strategies, and communication protocols (McKinsey & Company, 2021). For example, businesses can establish remote work policies, implement health and safety measures, and identify alternative suppliers to ensure operational continuity. Regularly updating and testing the crisis management plan ensures that businesses are prepared to respond swiftly and effectively to unforeseen disruptions.

Diversify Revenue Streams and Supply Chains

Diversification is a key strategy for reducing dependence on a single source of income or supply chain. Businesses should explore opportunities to diversify their revenue streams by entering new markets, developing new products, or adopting innovative business models (Brynjolfsson et al., 2020). For instance, during the COVID-19 pandemic, many restaurants expanded their offerings to include meal kits and grocery items, creating new revenue streams while adapting to changing consumer preferences (Bartik et al., 2020).

Similarly, businesses should diversify their supply chains to reduce vulnerability to disruptions. This can be achieved by sourcing materials from multiple suppliers, localizing production, and investing in inventory management systems (Ivanov, 2021). Diversification not only enhances resilience but also provides businesses with greater flexibility to adapt to changing market conditions.

Invest in Digital Transformation

Digital transformation is a critical enabler of business resilience during zoonotic disease outbreaks. Businesses should invest in technologies such as cloud computing, e-commerce platforms, and remote collaboration tools to maintain operations and serve customers effectively (Bughin et al., 2020). For example, cloud-based enterprise resource planning (ERP) systems enable businesses to monitor inventory, manage finances, and coordinate supply chains in real time, reducing the impact of disruptions (Ivanov, 2021).

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Additionally, businesses should leverage data analytics and artificial intelligence (AI) to gain insights into market trends, customer behavior, and operational performance. These technologies enable businesses to make informed decisions and respond quickly to changing circumstances (World Economic Forum, 2021). Investing in digital transformation not only enhances resilience during crises but also positions businesses for long-term growth in an increasingly digital economy.

Strengthen Stakeholder Relationships

Strong relationships with stakeholders, including employees, customers, suppliers, and investors, are essential for business resilience. During zoonotic disease outbreaks, businesses should prioritize transparent and proactive communication with stakeholders to build trust and foster collaboration (ILO, 2020). For example, businesses can provide regular updates on their response efforts, offer flexible payment terms to customers, and negotiate mutually beneficial agreements with suppliers.

Engaging employees is particularly important, as they are a critical asset during crises. Businesses should invest in employee well-being, provide training and development opportunities, and foster a culture of resilience and adaptability (McKinsey & Company, 2021). By strengthening stakeholder relationships, businesses can build a supportive network that enhances their ability to navigate challenges and recover from disruptions.

Monitor and Adapt to Regulatory Changes

Zoonotic disease outbreaks often lead to changes in government policies and regulations, which can have significant implications for businesses. Businesses should actively monitor regulatory developments and adapt their strategies accordingly (OECD, 2021). For example, during the COVID-19 pandemic, many businesses benefited from government relief programs, such as tax deferrals and loan guarantees, by staying informed and applying for available support (Granja et al., 2020).

Additionally, businesses should engage with industry associations and advocacy groups to stay informed about policy changes and contribute to the development of effective regulatory frameworks. By staying ahead of

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regulatory changes, businesses can minimize compliance risks and capitalize on new opportunities.

CONCLUSION

Zoonotic disease outbreaks pose significant financial challenges for businesses, but they also present opportunities for innovation and growth. By adopting proactive and adaptive financial management strategies, businesses can enhance their resilience and navigate the uncertainties of such crises. The recommendations outlined in this chapter—building cash reserves, developing crisis management plans, diversifying revenue streams and supply chains, investing in digital transformation, strengthening stakeholder relationships, and monitoring regulatory changes—provide a comprehensive framework for businesses to prepare for and respond to zoonotic disease outbreaks.

As the global economy continues to face the threat of zoonotic diseases, businesses must prioritize resilience and adaptability to ensure long-term success. By learning from past crises and embracing innovative solutions, businesses can not only survive but also thrive in the face of future challenges.

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CHAPTER 3
INSECT-BORNE ZOONOTIC DISEASES:
TRANSMISSION, IMPACT AND PREVENTION

G. GUNASEKAR¹

Asst. Prof. Dr. M. PAZHANISAMY²

¹Tamil Nadu Agricultural University, Ph. D Scholar, Department of Agricultural Entomology, Coimbatore, Tamil Nadu, India.

²Agriculture College and Research Institute, Department of Entomology, TNAU, Kudumiyamalai, Tamil Nadu, India

ZOONOTIC DISEASES: EPIDEMIOLOGY, TRANSMISSION, AND CONTROL STRATEGIES

INTRODUCTION

Zoonotic diseases transferred by insects, known as vector-borne zoonotic diseases, are illnesses that spread from animals to humans through the bites of infected insects such as mosquitoes, ticks, fleas, and sandflies. These vectors act as carriers, picking up pathogens from one host (often animals) and transmitting them to another host, including humans. The transmission of zoonotic diseases by insects is a major public health concern due to the widespread distribution of insect vectors and their ability to spread quickly in favorable environments. Mosquitoes are perhaps the most well-known vectors, responsible for transmitting diseases like malaria and dengue. However, other insects, like ticks and fleas, play a significant role in the spread of diseases such as Lyme disease and plague. These diseases can have serious health impacts on humans and, in some cases, can cause widespread outbreaks. Efforts to control vector-borne zoonotic diseases include controlling the insect populations, improving sanitation, and promoting awareness of prevention strategies. As urbanization, climate change, and environmental disruption continue to increase the geographic range of insect vectors, the need for coordinated global efforts to manage and reduce the impact of zoonotic diseases has never been more urgent. By focusing on prevention, early detection, and response, we can reduce the burden of insect-borne zoonotic diseases and safeguard public health worldwide.

1. THE ROLE OF INSECT VECTORS IN DISEASE TRANSMISSION

Insect vectors are key players in the transmission of zoonotic diseases, facilitating the spread of viruses, bacteria, and parasites between animals and humans. Mosquitoes, ticks, flies, and fleas are among the most common vectors, each capable of carrying specific pathogens. Although the insects themselves don't cause the diseases, they act as "vehicles" by transmitting pathogens from infected animals to humans or other animals, contributing to the global burden of zoonotic diseases (World Health Organization, 2020). The transmission process typically begins when a vector bites an infected animal, ingesting the pathogen in the process. This pathogen multiplies within the insect or remains within its system, ready to be transferred to a new host during the

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next bite. Depending on the type of pathogen and vector, the risk of disease transmission can increase in areas with high insect populations or environmental conditions that favor their breeding (Centers for Disease Control and Prevention, 2021). A clear example of this is the transmission of West Nile Virus. This virus primarily circulates in bird populations, but mosquitoes that feed on both birds and mammals can transfer the virus to humans, leading to outbreaks. Other common vector-borne zoonotic diseases include malaria, Lyme disease, and Zika virus, all of which are transmitted through insect bites (Kilpatrick, 2011). The role of insect vectors in disease transmission highlights the importance of monitoring and controlling vector populations to prevent the spread of zoonotic diseases and protect public health.

The Transmission Process Typically Follows These Steps

- a) **Pathogen Acquisition:** An insect vector bites an infected animal, ingesting the pathogen along with the blood meal. The pathogen then enters the insect's body and may multiply or reside within it.
- b) **Pathogen Transfer:** When the infected insect bites another host, it transfers the pathogen through its saliva or other secretions, potentially infecting the new animal or human host.

Insects Transmit Zoonotic Diseases Through Several Mechanisms

- **Bites:** The most common method of transmission is through insect bites, where pathogens are injected directly into the host's bloodstream. Mosquitoes, for instance, transmit malaria through this method, injecting the *Plasmodium* parasite during feeding (Centers for Disease Control and Prevention, 2021).
- **Regurgitation:** Insects like tsetse flies transmit diseases by regurgitating partially digested food while feeding. This regurgitated material can contain pathogens, which are then transferred to the host, potentially leading to infection. The *Trypanosoma brucei* parasite, responsible for African sleeping sickness, is commonly transmitted in this way (World Health Organization, 2020).

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- **Defecation:** Insects such as triatomine bugs defecate near a bite or wound, and if the host inadvertently scratches the area, the pathogens in the feces can enter the bloodstream. This is the transmission method for Chagas disease, caused by the *Trypanosoma cruzi* parasite (Bern, 2015).

1.1 Types of Pathogens Transmitted by Insect Vectors

Insect vectors are responsible for transmitting various types of pathogens that cause zoonotic diseases. These pathogens include viruses, bacteria, parasites, and protozoa, with each type leading to distinct illnesses in humans. Below are the key categories of pathogens spread by insect vectors and common zoonotic diseases associated with them:

Viral Pathogens

Viruses are the smallest and simplest infectious agents, consisting of genetic material encased in a protein shell. They replicate by invading a living host, taking over the host's cells, and multiplying rapidly. This can overwhelm the immune system and cause disease. Common viral zoonotic diseases transmitted by mosquitoes include:

- **Dengue virus:** Spread by *Aedes* mosquitoes, dengue fever can cause flu-like symptoms and, in severe cases, progress to life-threatening hemorrhagic fever (World Health Organization, 2022).
- **West Nile virus:** Carried by mosquitoes, this virus primarily infects birds but can spread to humans, leading to neurological symptoms in severe cases (Centers for Disease Control and Prevention, 2021).
- **Zika virus:** Transmitted by *Aedes* mosquitoes, Zika virus can cause mild symptoms in adults, but it is especially dangerous for pregnant women, as it can result in congenital disabilities such as microcephaly (World Health Organization, 2021).

Bacterial Pathogens

Bacteria are more complex than viruses and can cause diseases by rapidly multiplying within the host, damaging tissues, and sometimes producing toxins. Several insect vectors, such as ticks, fleas, and lice, transmit bacterial zoonotic diseases, including:

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- Lyme disease: Caused by the bacterium *Borrelia burgdorferi* and transmitted through black-legged tick bites. According to the CDC, an estimated 476,000 people are diagnosed and treated for Lyme disease annually in the United States (Centers for Disease Control and Prevention, 2021).
- Typhus: Spread by lice, fleas, and chiggers, typhus is a rare bacterial disease that can lead to outbreaks in areas with overcrowding and poor hygiene (World Health Organization, 2020).
- Plague: The bubonic plague, caused by *Yersinia pestis*, is mainly transmitted by fleas that have fed on infected rodents. While rare today, the plague still exists in certain regions, with occasional outbreaks (World Health Organization, 2020).

These bacterial pathogens can severely impact human health by invading and rapidly multiplying in tissues, and in some cases, producing toxins that exacerbate illness.

1.2 Zoonotic Diseases Transferred by Insects

Malaria

- **Vector:** *Anopheles* mosquitoes
- **Pathogen:** *Plasmodium* parasites (*Plasmodium falciparum*, *Plasmodium vivax*, *Plasmodium malariae*, *Plasmodium ovale*)
- **Symptoms:** Fever, chills, headache, muscle aches, fatigue, nausea, vomiting, and diarrhea. Severe cases can cause anemia, organ failure, and death.
- **Transmission:** Mosquitoes pick up the parasite from infected humans and pass it on through bites.

Dengue Fever

- **Vector:** *Aedes* mosquitoes (primarily *Aedes aegypti* and *Aedes albopictus*)
- **Pathogen:** Dengue virus (DENV-1, DENV-2, DENV-3, DENV-4)

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- **Symptoms:** High fever, severe headache, pain behind the eyes, joint and muscle pain, rash, and mild bleeding (nose or gums). Severe cases may develop into dengue hemorrhagic fever.
- **Transmission:** Infected mosquitoes bite humans, spreading the virus.

Lyme Disease

- **Vector:** *Ixodes* ticks (commonly known as deer ticks or black-legged ticks)
- **Pathogen:** *Borrelia burgdorferi* bacteria
- **Symptoms:** Fever, headache, fatigue, and a characteristic skin rash called erythema migrans (which expands in a “bull’s-eye” pattern). Can lead to joint pain, neurological problems, and heart issues if untreated.
- **Transmission:** Ticks pick up the bacteria from infected animals (especially mice and deer) and transmit it to humans through bites.

West Nile Virus

- **Vector:** *Culex* mosquitoes
- **Pathogen:** West Nile virus
- **Symptoms:** Fever, headache, body aches, joint pains, vomiting, diarrhea, or rash. Severe cases can lead to neurological diseases like encephalitis or meningitis.
- **Transmission:** Mosquitoes get infected by feeding on infected birds and transmit the virus to humans and other animals.

Chikungunya

- **Vector:** *Aedes* mosquitoes (*Aedes aegypti* and *Aedes albopictus*)
- **Pathogen:** Chikungunya virus
- **Symptoms:** Sudden onset of fever and severe joint pain, particularly in the hands, wrists, and ankles. Other symptoms include headache, muscle pain, joint swelling, and rash.
- **Transmission:** Infected mosquitoes transmit the virus to humans through bites.

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Zika Virus

- **Vector:** *Aedes* mosquitoes (*Aedes aegypti* and *Aedes albopictus*)
- **Pathogen:** Zika virus
- **Symptoms:** Fever, rash, headache, joint pain, conjunctivitis (red eyes), and muscle pain. Zika virus can cause congenital disabilities like microcephaly if contracted by pregnant women.
- **Transmission:** Mosquito bites are the primary route, though Zika can also be sexually transmitted.

Plague

- **Vector:** Fleas (primarily *Xenopsylla cheopis*)
- **Pathogen:** *Yersinia pestis* bacteria
- **Symptoms:** Fever, chills, headache, muscle aches, and swollen lymph nodes (buboes). Other forms of the plague, such as septicemic and pneumonic, can develop.
- **Transmission:** Fleas become infected by biting rodents and transmit the bacteria to humans through bites.

Chagas Disease

- **Vector:** Triatomine bugs (kissing bugs)
- **Pathogen:** *Trypanosoma cruzi* parasite
- **Symptoms:** In the acute phase: fever, fatigue, body aches, headache, rash, loss of appetite, diarrhea, and vomiting. In the chronic phase, it can lead to heart disease and digestive system complications.
- **Transmission:** Triatomine bugs defecate after biting, and the parasites in their feces enter the host through the bite wound or mucous membranes.

Typhus

- **Vector:** Fleas, lice, and chiggers
- **Pathogen:** *Rickettsia* bacteria
- **Symptoms:** Fever, chills, rash, headache, muscle aches, and sometimes confusion. Severe cases can lead to complications like pneumonia or organ failure.

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- **Transmission:** Lice, fleas, and chiggers carry *Rickettsia* bacteria, which enter the bloodstream through bites.

Leishmaniasis

- **Vector:** Sandflies
- **Pathogen:** *Leishmania* parasites
- **Symptoms:** Cutaneous leishmaniasis causes skin sores. Visceral leishmaniasis can affect internal organs, causing fever, weight loss, and enlargement of the spleen and liver.
- **Transmission:** Sandflies bite infected animals or humans and spread the parasites through subsequent bites.

Yellow Fever

- **Vector:** *Aedes* and *Haemagogus* mosquitoes
- **Pathogen:** Yellow fever virus
- **Symptoms:** Fever, chills, headache, back pain, and fatigue. Severe cases can cause jaundice, bleeding, and organ failure.
- **Transmission:** Mosquitoes spread the virus to humans through bites after feeding on infected monkeys or humans.

Rift Valley Fever

- **Vector:** *Aedes* mosquitoes
- **Pathogen:** Rift Valley fever virus
- **Symptoms:** Fever, weakness, dizziness, and muscle pain. Severe cases can lead to hemorrhagic fever or encephalitis.
- **Transmission:** Infected mosquitoes bite livestock and humans, spreading the virus.

Onchocerciasis (River Blindness)

- **Vector:** Blackflies
- **Pathogen:** *Onchocerca volvulus* (a parasitic worm)
- **Symptoms:** Intense itching, skin rashes, and eye disease that can lead to blindness.

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- **Transmission:** Blackflies pick up the parasite from infected humans and spread it through bites.

Japanese Encephalitis

- **Vector:** *Culex* mosquitoes
- **Pathogen:** Japanese encephalitis virus
- **Symptoms:** Fever, headache, vomiting, confusion, and seizures. Severe cases can lead to encephalitis and death.
- **Transmission:** Mosquitoes transmit the virus to humans after feeding on infected pigs or birds.

African Sleeping Sickness (Trypanosomiasis)

- **Vector:** Tsetse flies
- **Pathogen:** *Trypanosoma brucei* parasites
- **Symptoms:** Fever, headache, joint pains, and itching. In the second stage, neurological symptoms develop, including confusion and disrupted sleep patterns, leading to death if untreated.
- **Transmission:** Tsetse flies bite infected animals or humans, spreading the parasites to new hosts.

2. PREVENT THE SPREAD OF ZOONOTIC DISEASES

Preventing the spread of vector-borne zoonotic diseases requires a combination of personal, community, and environmental strategies. While complete eradication of these diseases is difficult, reducing exposure to vectors like mosquitoes, ticks, and fleas can significantly lower the risk of transmission. The following measures can help slow the spread of zoonotic diseases.

Reducing Insect Habitats

- **Action:** Eliminate standing water around your home, such as in buckets, birdbaths, plant saucers, or any containers that can collect rainwater.
- **Benefit:** Standing water serves as a breeding ground for mosquitoes, a major vector for diseases like malaria, dengue, and Zika. Reducing their habitats can decrease mosquito populations and, in turn, the likelihood of disease transmission.

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Using Insecticides and Repellents

- **Action:** Apply insect repellents containing DEET or other effective chemicals when spending time outdoors, particularly during peak mosquito activity times (dawn and dusk). Use insecticides inside and around your home to control vector populations.
- **Benefit:** Personal repellents help protect against mosquito and tick bites, reducing the risk of contracting diseases like Lyme disease, West Nile virus, and chikungunya. Insecticides can limit the population of insects in your immediate environment.

Vaccinating Pets

- **Action:** Keep pets up to date with vaccinations, especially for diseases like rabies, and use veterinary-recommended tick and flea preventatives.
- **Benefit:** Pets that spend time outdoors are at higher risk of exposure to zoonotic diseases through insect bites. Vaccinating and treating pets reduces the likelihood of them becoming carriers of diseases that can spread to humans.

Additional Strategies

- **Wearing Protective Clothing:** Long sleeves, pants, and socks can prevent insect bites, especially when hiking or spending time in tick- and mosquito-infested areas.
- **Using Bed Nets:** In areas where insect-borne diseases are prevalent, sleeping under bed nets can protect against nighttime insect bites.
- **Community Awareness and Education:** Informing communities about the risks of vector-borne diseases and promoting preventive measures is key to reducing disease incidence.

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CONCLUSION

Zoonotic diseases transmitted by insects pose a significant global health threat, affecting millions of people each year. Insects such as mosquitoes, ticks, fleas, and flies act as vectors for various pathogens, including viruses, bacteria, and parasites, that can cause life-threatening illnesses. Diseases like malaria, dengue fever, Lyme disease, and Zika virus highlight the critical role of insect vectors in disease transmission. Preventing the spread of these diseases requires an integrated approach that includes controlling insect populations through habitat management, using insecticides and repellents, and promoting personal protective measures. Vaccinating pets and livestock, educating communities, and enhancing surveillance systems are also key components of an effective prevention strategy.

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CHAPTER 4 AN OVERVIEW ON ZOONOTIC DISEASES

¹ Dr. M. K. Vijaya LAKSHMI

² Puniparthi SUNITHA

³Dr. Mahmut UÇAR

¹ Faculty Of Pharmacy, India

²B Pharm Student, Faculty Of Pharmacy, Bharath Institute Of Higher Education And Research, Selayur, Chennai, Tamilnadu

³ Yakutiye Municipality, 0000-0003-2740-6476

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INTRODUCTION

Zoonotic diseases, also known as zoonoses, are infectious diseases that are transmitted from animals to humans. These diseases can be caused by bacteria, viruses, parasites, or fungi and can spread through direct contact with animals, consumption of contaminated food or water, or through vectors like mosquitoes and ticks. Some zoonotic diseases can cause mild illnesses, while others may lead to severe or even fatal health conditions.[1] They can affect people of all ages, though individuals with weakened immune systems, pregnant women, and children are particularly vulnerable.[2]

1. IMPORTANCE OF UNDERSTANDING ZOONOTIC DISEASES

Zoonotic diseases pose significant threats to global health, economies, and food security. According to the World Health Organization (WHO), more than 60% of emerging infectious diseases in humans originate from animals.[3] These diseases can spread rapidly due to globalization, increased human-animal interactions, and climate change, which alters the habitats of disease-carrying species.[4]

Public Health Concern

Zoonotic diseases can lead to large-scale outbreaks and pandemics, such as the COVID-19 pandemic, which is suspected to have originated from an animal source. Effective monitoring and control of these diseases are crucial for preventing widespread illness and fatalities [5]

Economic Impact

Outbreaks of zoonotic diseases can disrupt economies by affecting agriculture, livestock industries, and international trade. For example, outbreaks of avian influenza and foot-and-mouth disease have led to significant economic losses due to culling of infected animals and trade restrictions [6]

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Food Safety and Security

Contaminated animal products can transmit zoonotic pathogens, leading to foodborne illnesses such as salmonellosis and E. coli infections. Ensuring proper food handling, sanitation, and monitoring systems in the food supply chain is critical to reducing disease transmission [7]

Biodiversity and Environmental Impact

Zoonotic diseases can also affect wildlife populations, leading to biodiversity loss and ecological imbalances. Habitat destruction and deforestation increase human-wildlife interactions, raising the risk of new zoonotic diseases emerging [8][9]

Globalization and Travel

With increased international travel and trade, zoonotic diseases can spread across borders more rapidly. Understanding these diseases allows for better preparedness, surveillance, and response strategies at the global level [10]

One Health Approach

A holistic approach that integrates human, animal, and environmental health—known as the One Health approach—is essential to addressing zoonotic diseases effectively. Collaboration between veterinarians, public health officials, ecologists, and policymakers helps in early detection and prevention of potential outbreaks [11]

By increasing awareness, investing in research, and strengthening healthcare and surveillance systems, zoonotic diseases can be better managed, ultimately protecting human and animal populations worldwide [12]

2. TYPES OF ZOONOTIC DISEASES

Zoonotic diseases can be classified into different categories based on their causative agents. The major types include:

2.1 Bacterial Zoonoses

These are diseases caused by bacteria that can be transmitted from animals to humans. [13]

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Examples include:

- **Anthrax** (*Bacillus anthracis*): Can be contracted through contact with infected animals or contaminated animal products [14]
- **Tuberculosis** (*Mycobacterium bovis*): Affects cattle and can be transmitted to humans through unpasteurized dairy products.
- **Leptospirosis** (*Leptospira* spp.): Spread through contaminated water or direct contact with infected animal urine.
- **Salmonellosis** (*Salmonella* spp.): Caused by consuming contaminated food of animal origin, such as eggs, meat, or dairy [15]

2.2 Viral Zoonoses

These diseases are caused by viruses that can cross from animals to humans[16]

Examples include:

- **Rabies**: A fatal disease transmitted through the bite of infected animals, particularly dogs and bats.
- **Ebola Virus Disease**: Believed to be transmitted from fruit bats and other wildlife to humans.
- **Avian Influenza (Bird Flu)**: Caused by *H5N1* or *H7N9* strains, transmitted through contact with infected poultry.
- **COVID-19 (Coronavirus Disease 2019)**: Likely originated from bats and possibly transmitted through an intermediate host [17][18]

2.3 Parasitic Zoonoses

These diseases are caused by parasites that can infect both animals and humans. Examples include

- **Toxoplasmosis** (*Toxoplasma gondii*): Often spread through cat feces or consumption of undercooked meat.
- **Echinococcosis (Hydatid Disease)**: Caused by tapeworms from the *Echinococcus* species, transmitted through contact with infected dogs or contaminated food
- **Trypanosomiasis (Sleeping Sickness and Chagas Disease)**: Transmitted by insect vectors such as tsetse flies and kissing bugs.

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- **Leishmaniasis:** Spread by sandflies, affecting both humans and animals [19][20]

2.4 Fungal Zoonoses

Fungal infections that can spread from animals to humans include:

- **Ringworm (Dermatophytosis):** A contagious skin infection caused by fungi from animals such as cats, dogs, and cattle.
- **Histoplasmosis:** Caused by *Histoplasma capsulatum*, found in bird and bat droppings, and inhaled by humans.
- **Cryptococcosis:** Associated with pigeon droppings, leading to severe respiratory and neurological conditions in immunocompromised individuals [21][22]

3. MODES OF TRANSMISSION

Zoonotic diseases can spread from animals to humans through various transmission routes [23]

1. **Direct Contact:** Occurs when humans come into direct physical contact with infected animals, their bodily fluids (saliva, blood, urine), or tissues.

Examples: Rabies (through animal bites), Brucellosis (from handling infected livestock) [24]

2. **Indirect Contact:** Involves exposure to contaminated environments, surfaces, or objects carrying infectious agents.

Examples: Leptospirosis (contact with contaminated water), Ringworm (contact with infected soil or animal bedding).

3. **Vector-Borne Transmission:** Involves insects and arthropods (e.g., mosquitoes, ticks, fleas) that carry and transmit pathogens between animals and humans.

Examples: Lyme disease (tick-borne), Malaria (mosquito-borne), Plague (flea-borne) [25]

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4. **Foodborne Transmission:** Occurs when humans consume contaminated food products derived from infected animals (meat, dairy, eggs) or unclean produce.

Examples: Salmonellosis (from contaminated poultry and eggs), Bovine Tuberculosis (from unpasteurized milk) [26]

5. **Airborne Transmission:** Inhalation of infectious particles from animal respiratory secretions or droppings.

Examples: Q fever (inhalation of *Coxiella burnetii* from livestock), Avian Influenza (airborne poultry droppings).

6. **Waterborne Transmission:** Infection through consumption of or exposure to water contaminated with animal feces or urine.

Examples: Cryptosporidiosis, Leptospirosis [27]

4. COMMON ZOONOTIC DISEASES

Some of the most commonly occurring zoonotic diseases worldwide include.

1. **Rabies:** A fatal viral disease transmitted through the bite of infected animals, particularly dogs and bats.
2. **Influenza (Bird Flu & Swine Flu):** Viral infections transmitted from poultry or pigs to humans, leading to respiratory illnesses.
3. **Tuberculosis:** A bacterial infection that can be transmitted from cattle to humans through unpasteurized dairy products.
4. **Brucellosis:** A bacterial disease transmitted through direct contact with infected animals or consumption of contaminated animal products.
5. **Salmonellosis:** A bacterial infection caused by consuming contaminated food of animal origin, such as eggs, meat, or dairy.

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6. **Leptospirosis:** A bacterial disease spread through contaminated water or direct contact with infected animal urine.
7. **Lyme Disease:** A bacterial infection transmitted by tick bites, leading to various health issues .
8. **Toxoplasmosis:** A parasitic disease often spread through cat feces or consumption of undercooked meat.
9. **Ebola Virus Disease:** A viral hemorrhagic fever believed to be transmitted from fruit bats and other wildlife to humans.
10. **COVID-19:** A viral respiratory illness likely originated from bats and possibly transmitted through an intermediate host. [28][29][30][31][32]

5. IMPACT ON HUMAN HEALTH

Zoonotic diseases can have profound impacts on human health, ranging from mild symptoms to severe illnesses and fatalities. The severity and nature of the impact depend on the specific disease and the individual's health status [33]

- A. **Morbidity and Mortality:** Some zoonotic diseases, such as rabies and Ebola, have high fatality rates if not promptly treated. Others, like Lyme disease, can cause chronic health issues if not properly managed [34].
- B. **Economic Burden:** Outbreaks of zoonotic diseases can lead to significant economic losses due to healthcare costs, loss of productivity, and impacts on industries like agriculture and tourism.
- C. **Social Disruption:** Widespread outbreaks can cause social disruption, including travel restrictions, quarantine measures, and public fear, as seen during the COVID-19 pandemic [35],[36].

6. ROLE OF ANIMALS IN DISEASE SPREAD

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Animals play a pivotal role in the transmission of zoonotic diseases, serving as reservoirs or carriers of pathogens that can infect humans. These pathogens include viruses, bacteria, parasites, and fungi. [37] Transmission can occur through direct contact with animals, indirect contact via contaminated environments, consumption of contaminated food or water, or through vectors like mosquitoes and ticks [38] .

1. **Prevention and Control Strategies** Effective prevention and control of zoonotic diseases require a multifaceted approach:
2. **Public Awareness and Education:** Educating communities about safe animal handling practices, the importance of hygiene, and the risks associated with zoonotic diseases.
3. **Vaccination Programs:** Implementing vaccination campaigns for both humans and animals to reduce the prevalence of diseases like rabies [39],[40].
4. **Surveillance and Monitoring:** Establishing robust systems to detect and respond to outbreaks promptly, minimizing the spread of diseases.
5. **Improved Sanitation and Hygiene:** Ensuring access to clean water, proper waste disposal, and food safety measures to reduce transmission risks.
6. **Vector Control:** Managing populations of disease-carrying vectors, such as mosquitoes and ticks, through environmental management and chemical control methods [41],[42].

7. GLOBAL EFFORTS TO COMBAT ZOONOTIC DISEASES

Addressing zoonotic diseases is a global priority[43] , necessitating coordinated efforts:

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1. **One Health Approach:** This strategy emphasizes the interconnectedness of human, animal, and environmental health, promoting collaborative efforts across sectors to prevent and control zoonotic diseases [44].
2. **International Collaboration:** Organizations like the World Health Organization (WHO), the Food and Agriculture Organization (FAO), and the World Organisation for Animal Health (WOAH) work together to develop guidelines, share data, and support countries in managing zoonotic threats [45].
3. **Research and Development:** Investments in research aim to understand zoonotic pathogens better and develop diagnostics, treatments, and vaccines.
4. **Capacity Building:** Enhancing the capabilities of healthcare systems worldwide to detect, respond to, and manage zoonotic disease outbreaks effectively [46].

By implementing these strategies and fostering global collaboration, the spread of zoonotic diseases can be mitigated, safeguarding both human and animal health [47].

CONCLUSION

Zoonotic diseases, responsible for over 60% of emerging infectious diseases in humans, pose significant threats to global health, economies, and biodiversity [48]. The recent outbreak of a mysterious illness in the Democratic Republic of Congo, resulting in over 60 fatalities and affecting more than a thousand individuals, underscores the urgency of addressing these threats. Effective management of zoonotic diseases necessitates a comprehensive understanding of their various types—bacterial, viral, parasitic, and fungal—and their diverse transmission modes, including direct contact, indirect contact, vector-borne, foodborne, airborne, and waterborne pathways. Implementing the One Health approach, which integrates human, animal, and environmental health disciplines, is crucial for early detection, prevention, and control of

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zoonotic diseases [49]. This collaborative strategy involves coordinated efforts among veterinarians, public health officials, ecologists, and policymakers to monitor and mitigate potential outbreaks. For instance, the Centers for Disease Control and Prevention (CDC) established a One Health Office in 2009, becoming the first U.S. federal agency to dedicate resources to this field. The economic implications of zoonotic diseases are profound, as outbreaks can disrupt agriculture, livestock industries, and international trade. For example, the 1999 West Nile virus outbreak in New York City highlighted the critical role of veterinarians in public health and led to the integration of veterinary expertise into public health departments. Additionally, zoonotic diseases can compromise food safety and security, leading to foodborne illnesses that affect public health [50].

Environmental factors, such as habitat destruction and deforestation, exacerbate the risk of zoonotic disease emergence by increasing human-wildlife interactions. The Nipah virus outbreak in Kerala, India, which led to fatalities and the shutdown of schools and public spaces, exemplifies the consequences of such environmental disruptions [51]. In conclusion, addressing the challenges posed by zoonotic diseases requires a multifaceted approach that includes enhancing surveillance systems, investing in research, promoting intersectoral collaborations, and adopting the One Health framework. By doing so, we can better anticipate, prevent, and respond to zoonotic threats, thereby safeguarding the health of human and animal populations globally [52].

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CHAPTER 5 ZOONOTIC DISEASES

Dr. Danish RIAZ¹
Muhammad YOUSIF¹
Dr. Fayyaz RASOOL¹
Dr. Mati ULLAH¹
Dr. Syed Makhdoom HUSSAIN²
Dr. Javed Ahmad UJAN³
Dr. Khadim Hussain MEMON³
Dr. Waheed Ali PANHWAR⁴
Dr. Awais MAQSOOD⁵

¹University of Education, Department of Zoology, Division of Science and technology, Lahore Pakistan

² Department of Zoology, Government College University, Faisalabad Pakistan

³ Department of Zoology, Shah Abdul Latif University, Khairpur Pakistan

⁴ Department of Zoology, University of Sindh, Jamshoro, Hyderabad, Pakistan

⁵ Department of Bioinformatics and Biotechnology, Government College University, Faisalabad Pakistan

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INTRODUCTION

Humans and animals are dependent upon environment for food, space, shelter, oxygen and other major supporting components for life, in the same way living organisms depend upon other living organism for its survival which is known as parasite. The parasite which cannot survive without its host organism is known as obligate parasite on other hand the parasite which can survive without its host is known as facultative parasite (Poulin, 2007). Zoonotic infectious diseases agents are parasite of human which are detrimental to human health causing serious infections (diseases). These parasite spread by animals to human being is known as zoonotic diseases. The zoonotic diseases are critical issue to public health in under developing countries causing serious health problems to human and may cause death if remain untreated .Efforts are made in all over the world to eradicate and minimize the zoonotic infectious diseases .Vaccines have developed for some zoonotic infectious diseases while other zoonotic diseases is still untreatable. A zoonotic infectious diseases agents may be unicellular prokaryotes example bacteria or multicellular fungus and a cellular viruses and prions (prions are Misfielded protein) spread from vertebrates carriers animals to human being (Han et al., 2016). The zoonotic causative agents have different forms and shapes among of these some are obligate parasite while other are facultative parasite as mentioned previously, the infectious zoonotic diseases spread either directly by living organisms (contact with host animal body fluid blood, saliva ,urine, body tissue and feces) or indirectly by environment through contaminated air ,water, food and other objects which are contaminated with infectious agents, diseases are also transmitted by transplantation of tissues from one human to other human. The animals which act as carrier of pathogen is known as reservoir (vector) which may affected or may remain safe. The terrorism which is launch against any community or country through zoonotic diseases is known as bioterrorism (living terrorism) (Sweeney et al., 2011). The zoonotic microorganisms are influenced by environmental factors such as humidity temperature. Some of the infectious agents is transmitted and cause infection hot weather while other transmitted and cause infection in cold weather. There are identified 1400 pathogens are discovered to affect human being among 216 viral infectious disease 529 bacterial and remaining are caused by fungus, helminthes and

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protozoans (Slingenbergh et al., 2004). Variation in pathogens and vector's environment contributes the appearing of new infectious zoonotic diseases these changes often change behavior of host animals. Variation in temperature shifts the animals from one geographic region to other one. Variation in rainfall cause drought so animals shifts to other geographical region. Colonization, globalization and exodus of animals also have negative effects on local population competition increases for food and breeding (Rudall, 2022). Loss of biodiversity by hunting and damaging natural habitat leads to stabilization of the ecosystem. Human can be protected from these diseases if the further deforestation and urbanization stop natural habitats of animals should not be disturb waste of factories should be discarded in proper places to avoid the natural habitat destruction .Environmental protection agencies should work and apply the laws to protect the natural environment (Booth et al., 2021). The usage of wildlife animal meat have risks for human beings the carried by wild animals generally not present in domesticated animals and consuming of the wild animals meat increasing the chances of the infectious zoonotic diseases (Booth, H., 2021). Avoiding unnecessary interaction with animals is the best way to decrease the chances of animal zoonotic diseases and the habitat of the wildlife also should be avoided for decreasing the chances of the infectious zoonotic diseases. Majority of the mammals are endemic of Australia, Africa, south America and central African republics united states of America most of the infectious zoonotic diseases are originate from that regions because of the biodiversity contains the vector animals for infectious zoonotic diseases vectors. The biodiversity includes primates, bat, and rodent orders (Recht et al., 2020). The origin zoonotic infectious diseases have been increasing because of deforestation. The zoonotic infectious agents effect the economy very badly every year 4 billion dollar spends on zoonotic infectious diseases treatment in United States of America. The zoonotic diseases decreases the livestock products because of sick and death of domestic animals and trade of animals among states banned and the costs of meats and livestock products increases. The zoonotic infectious diseases also have mental health stress especially incurable infectious zoonotic diseases so normal routine of the peoples disturbs.

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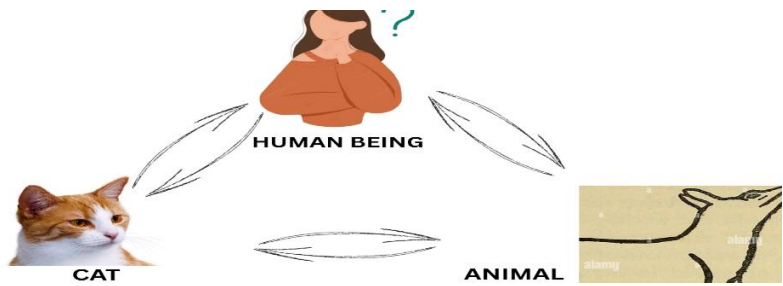


Figure 1: Shows the pattern of transmission of zoonotic diseases between animals and man and back to animals

Table 1: Shows infectious zoonotic parasitic diseases (Sanyaolu, 2016);(Weiss, 2008).

Scientific name	Infection	Caused by	morphology	Precautions	Infective stages	Active stages	Definitive host
<i>Entamoeba histolytica</i>	Amoebiasis Gastrointestinal tract cramps and dysentery	Intestinal parasite	Spherical	Practicing proper hygiene	Cyst stage	Trophozoitic stage	Human
<i>Toxoplasma gondii</i>	Toxoplasmosis Brain and eyes inflammation	Intracellular parasite	Clones, cysts	Proper cooking of meat and hygiene	Oocysts	Bradyzoitic And tachyzoitic stages	Domestic cat
<i>Balantidium Coli</i>	Balantidiosis Gastrointestinal tract issues	Intestinal extracellular parasite	Unicellular with macro and micro nucleus	Practicing Proper hygiene	Cystic stage	Trophozoitic Stage	Human
<i>Toxocara canis</i> <i>Toxocara cati</i> <i>species larvae</i>	Toxocariasis Abdominal pain cough sometimes swelling of eyes	Extracellular Intestinal parasite	Cylindrical Rounded body	Practicing proper hygiene	Egg stages	Eggs develop in adult stage	dog
<i>Ascaris lumbricoides</i>	Ascariasis Cough and respiration problems	Extracellular intestinal parasite	Cylindrical Rounded body	Practicing proper hygiene and personal protective	Egg stages	Larval stage	human

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CONTROL STRATEGIES**

				measure s			
<i>Trichinel la spiralis</i>	Trichinosis abdominal pain fever nausea and time encephaliti s	Intracell ular intestinal parasite	Cylindri cal rounded body	Proper cooking of meat and practicin g proper hygiene	1 st larval stage	Adult stage	Any animal

Table 2: Shows infectious viral zoonotic diseases (Sanyaolu, 2016);(Fowler, 1989)

Infections		Caused by	Vector animal
Dengue fever		Dengue virus	Ades mosquito
Hepatitis		Virus A,B,C,D,E	contamination
Measles		Rubeola virus	Air borne
Human virus	Immunodeficiency	HIV	Sexual contact and sharing needles

**1. EMERGENCE OF INFECTIOUS ZOONOTIC ANIMAL
DISEASES**

The rate of appearing of zoonotic infectious disease has been increasing more than past since 1970 thousands of zoonotic infectious diseases emerged this is threatening signals to world (Hayman et al., 2013). The zoonotic diseases are not new but increases its severity because changes in the environment by deforestation and encroachment in natural habitats of wild animals which results change the wildlife animals behavior and the vector animals moves to other geographical regions and causes the transmission zoonotic infectious diseases (Wang & Cramer, 2014). The environment has been changing because of changing in the techniques of agriculture methods and livestock methods unstable the relationships between parasite and host animals and causes food competition among parasitic animals other species thus increases the chances of the appearing of zoonotic diseases. Globalization results in the dispersion of vector animals in different geographical regions of the world by moving the

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infected human being and animals across the world to different regions. Animal tradition for different purposes among the different countries shifts and introduces new zoonotic diseases in new environment where the animals are adopted. Mutations and changes in the genetic material of infectious agent becomes antibiotic resistant another factor for the dispersion of diseases causative agents is biological factors genetic mutations (Tazerji et al., 2022 (Wang & Cramer, 2014)). The utilization of wild animals for food, medicines ,terrorism purpose increase the interaction of human and animals which cause the emergence of diseases (Magouras et al., 2020).

1.1 Types of Zoonotic Diseases

The division of the zoonotic infections into classes purpose was to arrange similar infections in the same class for detail study the classification was based on types of disease, mood of transmission, severity of infection and the origin of disease (Keenan et al., 2024). The agent for diseases are bacteria, virus, protozoans, aschelminthes, viron or parasite mode of transmission is direct or indirect require one host two hosts for completion its life cycle.

1.2.1 Bacterial Infections

These are the diseases of unicellular prokaryotic ancient creators and present everywhere in soil, air and water some of bacteria are aerobic lives in the place where oxygen is present while other are anaerobic lives where oxygen is not presents still others facultative parasite can grow either presence or absence of oxygen. They are also classified on their shapes spiral shaped, rod shaped, spiral shaped still on the interactions with human bacteria are divided into beneficial bacteria and harmful bacteria. Bacteria are transmitted by direct contact infected persons and by indirect method eating contaminated food, aerosol from one to another sexual contact and by zoonotic diseases infected animals (Christou, 2011). Bacteria cause serious diseases in multiple animals and human beings because high rate of multiplication sexually and asexually.

1.2.2 Viral Infections

These are tiny infectious agent obligate intracellular parasite only replicate with help host cell cellular machinery out of the host body virus is

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nonliving having either RNA or DNA as genetic material having outer protein capsule made by proteins. Viruses are transmitted by direct contact with infected animal or man and by indirect methods airborne, contaminated food, water and any other object.

1.2.3 Parasitic Zoonotic Infectious Disease

These are the infectious zoonotic diseases of unicellular protozoans, helminthes transmitted to human being by vector animals.

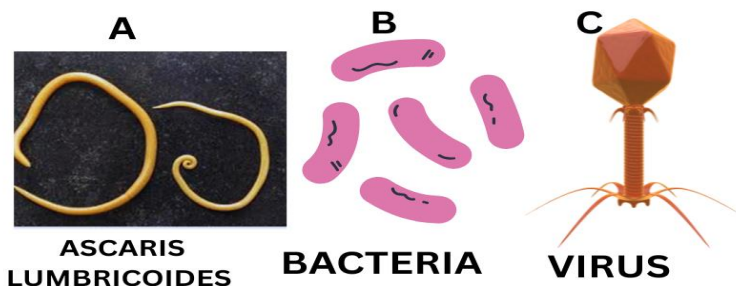


Figure 2: Shows (A) Ascaris Lumbricoides (B) Bacteria (C) Virus infectious zoonotic diseases agents

2. CAUTIONS AND CONTROL ACTIONS

Animals in forming the animals should be kept mobile because vectors animal exposure to pathogens is reduced (Zinsstag et al., 2016). Practice proper hygiene washing hands and exposed parts after dealing with vector animal. Proper medication should be used for animals before and after the infection. Peoples should be educated through seminars newspapers television channels about zoonotic diseases. Food should be tested before usage to decrease the chances spreading of zoonotic diseases. Protect the respiratory organs by using the airways protector during dealing with diseased animal. Diseased animals should be kept in isolated area to decreases the interaction with humans and other animals. Vector animals like rodentia orders animals and some insects should be kill to stop transmission from zoonotic animals to human being (Public & Veterinarians, 2008).

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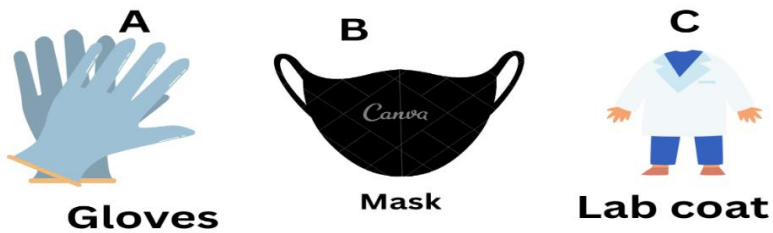


Figure 3: Shows (A) Gloves (B)Mask (C) Lab coat personal protective equipment

3. TRANSMISSION OF ZOONOTIC INFECTIOUS DISEASES

3.1 Contact Transmission

Some infectious zoonotic diseases transmitted by direct touch with infected animals. The contact may be either direct or indirect, in direct contact the diseases transferred by direct touch with infected animals or human where in indirect the diseases transferred through touching to objects which is already contaminated with zoonotic diseases agent(Public & Veterinarians, 2008).

3.2 Aerosol Transmission

Aerosols are particles which are float in air because of low weight. Transmission of zoonotic diseases agents from infected animals to human beings via respiration, the particles which are inhaled by human being from environment should be smaller than $5\mu\text{m}$ to inter in alveoli of lungs to cause infections. The aerosol diseases agents is able to travel in air long distance. The aerosol transmission may be either true air borne transmission, these are the zoonotic disease agents which remain for long time in air, or droplet transmission which are large particles remain for short duration in air. (Teller, 2009)

3.3 By Vector Animals

In this types of diseases transmissions, the zoonotic diseases agents transmitted either by direct contact with saliva, blood, urine, feces, and by the

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biting of the animals usually insects such as mosquito the pathogen transmitted to new host, or contact with contaminated water, soil, object or eating contaminated food. (Sanyaolu, 2016)

4. WORLD SURVEILLANCE AND PLAN FOR ZOONOTIC INFECTIOUS DISEASES

The increase in the ratio of diseases effect negatively on finance, health, and daily routine of the people in response to this situation an organization came into being under United States of America to minimize and eradicate the zoonotic infectious diseases (Woods et al., 2019). Global organization for animal species health categorized the zoonotic infectious diseases on the bases of severity and spreading ratio across the states. Global organizations for animal species health also characterized the diseases as its causative agents, vectors animals and the geographic location of the vector animals.

5. ENVIRONMENTAL CHANGE AND RISK MANAGEMENT FOR ZOONOTIC DISEASES

Sudden change in surroundings because disaster has effects on animals and human beings (Wannous, 2020) result in habitat change than animals migrate and species becomes under danger of extinction and changes the in the behavior of vector/carrier animals which than spread to new regions results chances increases of spreading of diseases droughts decreases availability of food and water which results animals becomes weak and more vulnerable to diseases(Kelly et al., 2017) evaluation and early detection of diseases in wild and domestic animals vaccination programs should be launched in animals forms the infected animals should be killed discarded properly human interactions should be decreases and public should be educated through awareness programs and television channels (Liverani et al., 2013).

6. FUTURE DIRECTIONS

Organizations should be made among the different states of the world for collaboration. Policies must be made for immediate response for eradication of diseases. Ecological and environment management be done to control deforestation and habitat destruction. Vaccines and medicines should be

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imported and developed in countries and should be used for immunization before the diseases and during diseases and newly techniques will be developed for treatment the diseased animals. The diseased animals should be treated in isolated laboratories (Bendrey & Martin, 2022). for identification genomic sequencing and molecular research will help the scientist the diagnosis, treatment of the diseases(Zhang et al., 2024) public must be educated about zoonotic diseases. Wildlife trade should be banned in the whole world.

CONCLUSION

In short zoonotic infectious diseases are threat to public health in all over the world as the transmitted to man from wild and domesticated animals causes pandemic diseases and economy loss because of its rapid rate of transmission. The zoonotic diseases have been increasing for decades because of climate change, urbanization, globalization, methods of agriculture forming, and unnecessary interactions with wild animals. Inadequate wildlife trade unethically and illegally among parties of the different countries lead to emergence of the zoonotic diseases. Illegal killing and the usage of animals for unethical purpose leads the extinctions of many species which causes instability in ecosystem another cause is the rapid medicine resistance of pathogens. These fatal diseases are needed to be controlled for balance ecosystem to eradicate these problems we need early detections of all the infectious zoonotic diseases monitoring the sick animal with advanced medical equipment in isolated labs. Public are needed to be aware through television channels, in schools and in newspapers. The animals should be domesticate in proper isolated forms and should be regulated by veterinary specialists. Organization should be made among the member states for participation and regulation for zoonotic infectious diseases. New technologies should be developed for eradication of zoonotic diseases and new roles should be made to stop illegal tradition, transportation, and unethical usage of wild and domesticated animals. The endangered threatened species should be protected in conserved environment. Research on molecular and cellular level should be done to develop advance medicine, vaccine to treat the zoonotic infectious diseases. Policies must be made to minimize the infection of zoonotic diseases.

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CHAPTER 6
DENGUE FEVER, A ZOONOTIC DISEASE IN
INDONESIA THAT THREATENS IN THE RAINY
SEASON

Rahmi AGUSTINA¹

¹ Biology in Universitas Jabal Ghafur Sigli Aceh, Indonesia

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INTRODUCTION

Zoonotic is a disease that can be transmitted from animals to humans or vice versa. This disease is caused by viruses, bacteria, fungi, parasites that originate from animals. Various types of zoonotic diseases include Rabies, Leptospirosis, Avian influenza, Anthrax, Dengue Fever, Malaria, Filariasis, Chikungunya, Zika, Japanese B. Encephalitis, Plague, Hantavirus, Ebola, Monkey Pox, Schistosomiasis, Taniasis, and Brucellosis. Zoonotic diseases are diseases or infections that are naturally transmitted between vertebrate animals and humans. In Indonesia, the livestock sector is very vulnerable to various zoonotic pathogens, which can come from viruses, bacteria, or parasites that lead to the potential for disease outbreaks. The emergence of new zoonoses is often associated with environmental changes, agricultural practices, and increasingly intensive interactions between humans and animals.

One of the zoonoses that is of serious concern in tropical and subtropical areas around the world, including in Indonesia, is dengue fever. Until the 17th week of 2024, there were 88,593 cases of Dengue Hemorrhagic Fever (DHF) with 621 deaths in Indonesia. Based on reports, out of 456 districts/cities in 34 provinces, deaths due to DHF occurred in 174 districts/cities in 28 provinces (Ministry of Health 2024). Dengue Hemorrhagic Fever (DHF) is a disease caused by the dengue virus which is transmitted through the bite of the *Aedes aegypti* mosquito. The *Aedes aegypti* mosquito is often known as the Black White Mosquito or Tiger Mosquito, namely its body has distinctive features with silvery white stripes and spots on a black base. The size of the *Aedes aegypti* mosquito is around 3-4 mm with a white ring on its legs, while its main characteristic is that there are 2 curved lines that are silvery white on both lateral sides and 2 parallel white lines on the median line of its back with a black base color (Irawan, 2019).

Here is the Taxonomy of *Aedes aegypti*:

- Kingdom: Animalia
- Phylum: Arthropoda
- Class: Insecta
- Order: Diptera
- Family: Culicidae
- Subfamily: Culicinae

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- Genus: Aedes
- Species: Aegypti

1. MORPHOLOGY OF AEDES AEGYPTI

1.1 Eggs

Black eggs with a size of ± 0.80 mm, oval in shape that floats one by one on the surface of clear water, or sticks to the walls of water containers. Eggs can survive up to ± 6 months in dry places. *Aedes aegypti* eggs are elliptical or elongated oval, look like black gauze weave, size 0.5-0.8 mm, polygonal surface, do not have a float base, and are separate from each other.



Figure 1. *Aedes aegypti* eggs

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1.2 Larvae

Aedes aegypti larvae have long, non-slender siphons and one pair of bristles, the anal saddle segment does not close the segment and the comb teeth are not lateral barbed. The size and anatomical completeness of the body are in accordance with the stage of development, namely: instar I larvae, the body is smaller, transparent in color, 1-2 mm long, the hair (spinae) on the chest (thorax) is not yet clear, and the respiratory funnel has not turned black. Instar II larvae get bigger, measuring 2.5-3.9 mm, the hair on the chest is not yet clear, and the respiratory funnel is already black, instar III larvae have begun to complete their anatomical structure. Instar IV larvae have complete anatomical structure and are clearly divided into head (cephal), chest (thorax), and abdomen (abdomen). After going through the fourth skin change, pupation occurs. The pupa is rather short, the body is bent, with the head-chest (cephalothorax) section larger when compared to the abdomen, so that it looks like a "comma" punctuation mark. On the back (dorsal) of the chest there is a pair of trumpet-like breathing apparatus. When the pupa development is complete, the pupa skin breaks and the adult mosquito comes out and flies (Karyanti & Hadinegoro, 2016).

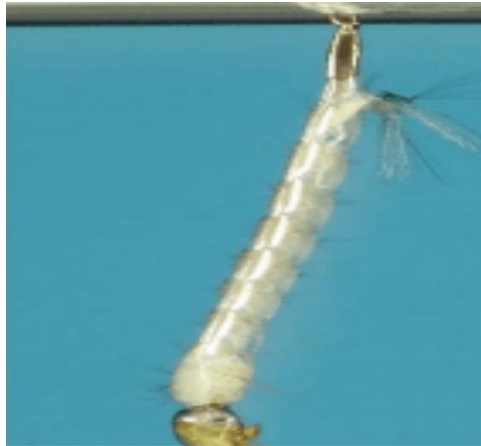


Figure 2. *Aedes aegypti* larvae

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1.2 Pupa

The pupa is shaped like a 'comma'. It is larger but more slender than the larva. *Aedes aegypti* pupae are smaller in size when compared to the average pupae of other mosquitoes.



Figure3. Pupa of *Aedes aegypti*

1.3 Adult Mosquitoes

Adult mosquitoes are smaller than the average mosquito and have a black base color with white spots on the body and legs. *Aedes aegypti* undergoes complete metamorphosis or perfect metamorphosis which goes through several stages, namely eggs, larvae, pupae and adults. *Aedes aegypti* is included in the Arthropoda phylum which is associated with viral diseases (Arbovirus). Its body consists of approximately 20 segments which are consolidated into three parts, namely, the head (caput), chest (thorax), and abdomen (abdomen). On the head are the mouthparts and eyes. The thorax consists of 3 segments which are in sequence from the front, namely the prothorax, mesothorax, and metathorax. In this section there are wings and legs while the abdomen contains the digestive tract and reproductive organs. The caput generally consists of the mouthparts, antennae, and compound eyes. The thorax of adult mosquitoes has silvery white or yellowish white spots on its black body. The dorsal part of the thorax has a distinctive patch in the form of 2 parallel lines in the middle and two curved lines on the edges. The abdomen of female mosquitoes is pointed at the end and has longer cerci than other mosquitoes. The mouthparts consist of six piercing stylets, namely: labrum stylet (hypopharynx labrum), two

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mandible stylets, two maxillary stylets, and hypofaring. The labium functions as a stylet sheath (rostrum). The maxillary palps are present, but the labial palps are absent. The salivary duct is located in the hypopharynx and the food duct is located between the grooved labrum and the mandible (Sari, 2017). When resting, the position of the *Aedes aegypti* is parallel to the surface area it lands on. In female mosquitoes, the mouth has a long proboscis to penetrate the skin and suck blood. While in male mosquitoes, the proboscis functions as a sucker for flower or plant nectar containing sugar. Female *Aedes aegypti* generally prefer to suck human blood because they need the protein contained in the blood for the formation of eggs so that they can hatch if fertilized by male mosquitoes. After being fertilized, the female mosquito will look for a place to perch in places that are rather dark and humid while waiting for the formation of its eggs (Hoedojo R and Zulhasril, 2008).



Figure 4. *Aedes aegypti*/Adult mosquitoes

2. LIFE CYCLE OF AEDES AEGYPTI

The life cycle is the development period of living things to reach the stage of perfection. The life cycle of the *Aedes aegypti* is a complete metamorphosis process because it experiences 4 stages of development, namely eggs, larvae, pupae, and imago (adults). The egg, larva, and pupa stages live in water (aquatic), mosquitoes live terrestrial (in the open air). Generally, eggs will hatch into larvae in about 2 days after the eggs are submerged in water. Female mosquitoes lay eggs on the walls of the container above the surface of

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the water in a state attached to the walls of their brood. Each time a female mosquito lays eggs, it can release 100 eggs. The aquatic phase lasts for 8-12 days, namely the larva stage lasts for 6-8 days, and the pupa stage lasts for 2-4 days. Growth from egg to adult mosquito lasts for 10-14 days. The lifespan of a mosquito can reach 2-3 months (Wahyuni, 2016; Fachenelli, 2023).

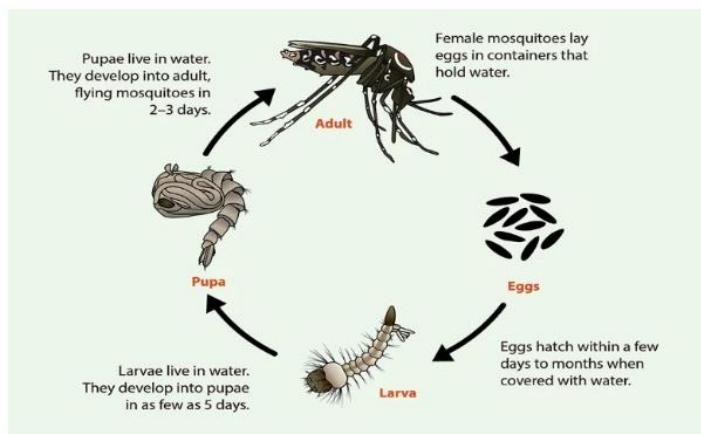


Figure 5. The life cycle of the *Aedes aegypti*

3. AEDES AEGYPTI BREEDING HABITAT

Aedes aegypti breeding habitats can be grouped as follows: Water reservoirs (TPA) for daily needs, such as: drums, reservoir tanks, jars, bathtubs/toilets, and buckets. Water reservoirs not for daily needs such as: bird drinking places, flower vases, ant traps, water drainage control tanks, refrigerator/dispenser water disposal places, clogged gutters, used goods (examples: tires, cans, bottles, plastic, etc.). Natural water reservoirs such as: tree holes, rock holes, leaf stalks, coconut shells, banana stalks and pieces of bamboo and brown/rubber shells (Chandell, 2024).

How Do Adult Mosquitoes Behave?

After emerging from the pupa, the mosquito rests on the water surface for a while. A few moments after that, the wings stretch to become stiff, so that the mosquito is able to fly in search of food. The biting activity of the *Aedes aegypti* usually starts in the morning and evening, with 2 peaks of activity between 09.00 -10.00 and 16.00 -17.00. After sucking blood, the mosquito will

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rest in a dark and humid place inside or outside the house, close to its breeding habitat. In that place, the mosquito waits for the maturation process of its eggs. After resting and the egg maturation process is complete, the female mosquito will lay her eggs on the surface of the water, then the eggs will move to the side and stick to the walls of the breeding habitat. In general, the eggs will hatch into larvae in ± 2 days. Every time she lays eggs, the female mosquito can produce ± 100 eggs. The eggs in a dry place (without water) can survive for ± 6 months, if these places are then flooded or the humidity is high, the eggs can hatch faster (Matthews, 2019).

4. DENGUE HEMORRHAGIC FEVER

Dengue Hemorrhagic Fever (DHF) is one of the endemic diseases throughout the tropics and some subtropics. The disease transmitted by the *Aedes aegypti* mosquito is a frightening specter because its transmission can occur quickly in an area. Even in 1 month, the number of DHF cases in endemic areas can reach dozens of humans infected with the dengue virus. This virus can live in living cells, so for its survival the virus must compete with the human cells it occupies, especially the need for protein. If the immune system of a person infected with the virus is low, as a result the tissue cells will be increasingly damaged if the virus develops. In Indonesia, dengue is a serious health problem because its prevalence is quite high and often causes extraordinary events. Cumulatively, in 2023 there were 114,720 cases reported with 894 deaths. In the 43rd week of 2024, 210,644 cases were reported with 1,239 deaths due to DHF which occurred in 259 districts/cities in 32 provinces. Cumulative dengue suspects reported through SKDR until the 43rd week reached 624,194 suspects. DHF complications can cause organ damage, such as the liver, heart, and lungs. Since early 2024, the increase in DHF cases and reported deaths has not only been in endemic areas, but also in areas that were previously free of DHF.

The increased risk of dengue transmission is also influenced by the El Nino phenomenon and climate change. "For the ASEAN region, currently, there have been approximately 219 thousand cases reported, with 774 deaths, and Indonesia itself is the largest contributor to dengue cases," the Ministry of Health (Kemenkes, 2024) has made various efforts to prevent extraordinary

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events due to dengue. One of these efforts is to continue to strive for a culture of eradicating mosquito nests by realizing the implementation of the one house one mosquito larvae movement. "The program also aims to prevent the breeding of mosquitoes, especially mosquito larvae in various places that are usually breeding grounds for mosquitoes, and the one house one mosquito larvae movement also contains a message for the prevention and control of dengue starting from home.

In 2024, the area affected by dengue fever will expand, reaching 482 districts/cities. In addition, in recent years, there has been a shortening of the annual cycle of this disease, from 10 years to three years or even less. Director of Prevention and Control of Infectious Diseases (P2PM) dr. Ina Agustina said, the trend of dengue fever over the past four years, the Incidence Rate (IR) of dengue fever has increased, while the Case Fatality Rate (CFR) or death rate due to dengue has decreased. Dengue fever cases tend to increase, but the death rate compared to the number of cases tends to decrease. The Ministry of Health has issued a national strategy for controlling dengue from 2021 to 2025 with six strategies. First, strengthening effective, safe, and sustainable vector management. Second, increasing access and quality of dengue management. Third, strengthening comprehensive dengue surveillance and responsive outbreak management. Fourth, increasing sustainable community involvement. Fifth, strengthening government commitment, program management policies, and partnerships. Sixth, developing studies, inventions, innovations, and research as the basis for evidence-based policies and program management. Various dengue control efforts have been carried out. Interventions in the environment, mosquitoes, and humans. Meanwhile, anticipatory steps that need to be taken at the beginning of the rainy season are as follows:

1. Implementing efforts to prevent the spread of DHF, including by mobilizing the community in the Eradication of Mosquito Nests through:
2. Draining and brushing the walls of water reservoirs such as bathtubs and drums.
3. Tightly closing water reservoirs such as drums, jars and others.
4. Recycling or reusing used goods that have the potential to be used as mosquito breeding grounds such as used bottles, used tires and others.

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Another way is to monitor water containers that can be a breeding ground for *Aedes aegypti* mosquitoes, namely 1) changing the water in flower vases once a week, draining the water in the base of flower pots, repairing water channels and others, 2) Optimizing community participation in implementing the One House One Larvae Monitoring Movement by appointing Larvae Monitoring Officers in each house to monitor and ensure that there are no larvae in their respective homes, 3) Conducting continuous counseling to the community through direct counseling and/or through print media and/or electronic media. Counseling is focused on prevention and recognition of dengue warning signs, so that there is no delay in referring patients from the community environment. By implementing these steps, the risk of zoonotic disease transmission can be significantly reduced, maintaining the health of individuals and the community.

CONCLUSION

The impact of zoonoses on public health can be very significant and includes various aspects, including:

1. **Human Health:** Zoonotic diseases can cause serious infections or even death in humans. Some diseases, such as rabies or Hantavirus, have a high mortality rate if not treated quickly.
2. **Burden on Health Systems:** Zoonotic outbreaks can place significant pressure on health systems, leading to increased health care costs and creating a need for more medical resources, including vaccination and treatment.
3. **Economic Impact:** Zoonotic diseases can cause significant economic losses. This includes medical costs, lost productivity due to disease, and impacts on the agricultural and livestock sectors which can suffer losses due to loss of livestock or reduced consumer demand.
4. **Psychosocial Impact:** Fear of the spread of zoonotic diseases can cause anxiety and stress in communities. Ongoing outbreaks can change community behavior, including avoidance of certain animals or changes in food consumption patterns.

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5. **Impact on Environmental Sustainability:** Efforts to control zoonoses can affect the environment, such as excessive use of pesticides to control vector populations, which can have negative impacts on ecosystems.
6. **International Spread:** Zoonoses, especially those originating from wild animals, can spread rapidly around the world, as demonstrated by the COVID-19 pandemic. This underscores the importance of global collaboration in zoonotic surveillance and prevention.
7. **Health Inequities:** Zoonotic diseases often disproportionately affect more vulnerable communities, such as those living in poverty or with limited access to health care, adding to inequities in the public health landscape.

Zoonoses are not only an individual health problem, but also create greater challenges for public health as a whole and require an integrated approach to their prevention and control.

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CHAPTER 7
**THE BURDEN OF ZOONOTIC DISEASES IN
NIGERIA: A REVIEW OF THE CURRENT STATE
AND FUTURE PROSPECTS**

Amusan Elizabeth TOLUWANI¹

Anifowoshe Isaac OLAOLUWA¹

Oladeji Deborah DARA²

¹ Department of Crop and Animal Science, Faculty of Agriculture, Ajayi Crowther University, P.M.B. 1066, Oyo, Oyo State, Nigeria.

²Department of Agricultural Production Technology, Moor Plantation, Ibadan, Oyo State, Nigeria

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INTRODUCTION

A zoonotic disease is any illness or infection that can be transmitted from vertebrate animals to humans (Van Dyke, 2011; Oregon, 2011). Zoonotic diseases, which are transmitted from animals to humans, pose significant public health concerns globally. These diseases have major impacts on human and animal health, livelihoods, and the economy, particularly in low- and middle-income countries (LMICs) like Nigeria (OIE, 2019; WHO, 2020). The interactions between humans, animals, and the environment play a significant role in the emergence and transmission of infectious diseases (Thompson and Kutz, 2019). According to the World Health Organization (WHO), any disease or infection naturally transmissible between vertebrate animals and humans is classified as a zoonosis (WHO, 2020).

Among human pathogens, approximately 61% are zoonotic in nature (Taylor *et al.*, 2001) and 75% of emerging infectious diseases are also zoonotic in nature (WHO, 2020). It is estimated that globally, zoonotic diseases cause over one billion cases of illness and millions of deaths annually. Around 60% of emerging infectious diseases worldwide are zoonotic, with over 30 new human pathogens detected in the last three decades, 75% of which originated in animals (Jones *et al.*, 2008.).

Nigeria, located in West Africa, has a population of over 200 million people, with a significant proportion engaged in agriculture and animal husbandry (National Bureau of Statistics, 2020). The country's geographic location, climate, and socio-economic factors create an environment conducive to the emergence and spread of zoonotic diseases with each zoonotic pathogen having varying epidemiology and severity (Kamani *et al.*, 2015). Nigeria ranks among the top 10 countries with the highest burden of infectious and zoonotic diseases globally (Ihekweazu *et al.*, 2021). In developing nations like Nigeria, the burden of zoonotic diseases is often underestimated due to weak surveillance systems, limited public awareness, limited laboratory capacity and scarcity of data (Kamani *et al.*, 2015; Munyua *et al.*, 2016). These make the control and prevention of zoonotic diseases in Nigeria to be facing several challenges. Additionally, the lack of effective coordination and collaboration among human and animal health sectors hinders the control and prevention of zoonotic diseases (OIE, 2019).

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In Nigeria, the burden of zoonotic diseases is substantial, with significant economic, social, and health implications. The presence of diverse wildlife, livestock, and human populations in close proximity increases the risk of zoonotic disease transmission (OIE, 2019). Zoonotic diseases such as rabies, leptospirosis, and Lassa fever are endemic in Nigeria, while others like avian influenza and Ebola have also caused significant outbreaks in recent years (NCDC, 2020; OIE, 2019). These diseases have significant impacts on human health, resulting in morbidity, mortality, and economic losses (Kamani *et al.*, 2015). For example, Lassa fever, a viral hemorrhagic fever, is endemic in Nigeria and causes significant morbidity and mortality, particularly during outbreaks (Ogbu *et al.*, 2007).

This chapter provides an overview of the burden of zoonotic diseases in Nigeria, including their impact on human and animal health. It reviews the current state of knowledge on zoonotic diseases in Nigeria, highlighting the challenges and opportunities for controlling and preventing these diseases. Finally, it discusses future prospects for research, policy and practice in zoonotic disease control and prevention in Nigeria.

1. ECONOMIC IMPACTS OF ZOONOTIC DISEASES

Nigeria, the most populous country in Africa with an estimated 236 million people (Worldometer, 2025), has one of the continent's largest livestock populations—19.5 million cattle, 72.5 million goats, and 41.3 million sheep (Onusi, 2017). The agricultural sector employs about 70% of Nigeria's workforce, with livestock production accounting for 6–8% of the national Gross Domestic Product (GDP) and 20–25% of agricultural GDP (Onusi, 2017).

Despite its economic significance, the livestock sector lacks adequate veterinary care and support systems, allowing zoonotic diseases to thrive. Many Nigerian households have close contact with domestic animals yet remain unaware of the public health risks posed by zoonotic infections (Pieracci *et al.*, 2016; McDaniel *et al.*, 2014). The intensification of livestock production due to the rising demand for animal protein further facilitates pathogen transmission at the human-animal-ecosystem interface (Jones *et al.*, 2013; Klous *et al.*, 2016). Even when animals do not succumb to zoonotic diseases, their health

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and productivity can be severely affected, leading to reductions of over 70% in meat, milk, and egg production. Additionally, diseases such as Bovine Spongiform Encephalopathy (BSE), avian influenza, and anthrax disrupt international trade in animals and animal products.

Zoonotic diseases, which are transmitted from animals to humans, have significant economic impacts on individuals, communities, and societies as a whole. These impacts can be direct or indirect and can affect various sectors, including agriculture, healthcare, and tourism.

1.1 Direct Economic Impacts

- **Livestock Production Losses:** Zoonotic diseases can lead to significant losses in livestock production, resulting in reduced income for farmers and the livestock industry as a whole (OIE, 2019).
- **Human Healthcare Costs:** Zoonotic diseases can result in significant healthcare costs, including hospitalization, treatment, and medication (WHO, 2020).
- **Loss of Productivity:** Zoonotic diseases can lead to loss of productivity, resulting in reduced economic output and income (Kamani *et al.*, 2015).

1.2 Indirect Economic Impacts

- **Trade and Commerce Disruptions:** Zoonotic disease outbreaks can lead to trade and commerce disruptions, resulting in economic losses for affected countries and industries (OIE, 2019).
- **Tourism and Travel Impacts:** Zoonotic disease outbreaks can lead to reduced tourism and travel, resulting in economic losses for affected countries and industries (WHO, 2020).
- **Food Safety and Security Concerns:** Zoonotic diseases can lead to food safety and security concerns, resulting in economic losses for affected countries and industries (FAO, 2018).
- **Psychological and Social Impacts:** Zoonotic diseases can have significant psychological and social impacts, including anxiety, stress, and social stigma (Kamani *et al.*, 2015).

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- **Loss of Human Capital:** Zoonotic diseases can result in loss of human capital, including reduced productivity and economic output (WHO, 2020).

Zoonotic diseases can also impose direct economic costs on livestock production, including: morbidity and mortality in food-producing animals, decreased output due to disease outbreaks and increased expenditure on veterinary care and treatments (Bennett and Ijpelaar, 2005). As an example, a study estimated that rabies costs Nigeria approximately ₦2.4 billion (approximately USD 6.7 million) annually in direct and indirect costs (Kamani *et al.*, 2015). Understanding the economic impacts of zoonotic diseases is crucial for developing effective prevention and control strategies.

2. CLASSIFICATION OF ZOONOTIC DISEASES

Zoonotic diseases are classified based on various criteria, including the type of causative pathogen and etiology, the mode of transmission, reservoir host and the severity of the disease. The comprehensive classifications of zoonotic diseases are stated below.

2.1 Based on Etiology

Bacterial zoonotic diseases include anthrax, salmonellosis, tuberculosis, Lyme disease, brucellosis and plague. Viral zoonotic diseases include rabies, ebola, avian influenza and HIV/AIDS. Parasitic zoonotic disease includes trichinosis, toxoplasmosis, malaria, echinococcosis. Example of fungal zoonotic disease is ringworm while an example of rickettsial zoonotic disease is Q-fever. Chlamydial zoonotic disease includes Psittacosis while mycoplasma zoonotic disease transfers *Mycoplasma pneumoniae* infection. Protozoal zoonotic diseases are diseases caused by acellular, non-viral pathogenic agents, such as mad cow disease and transmissible spongiform encephalopathies (Chomel, 2009).

2.2 Based on Mode of Transmission

Bacterial Zoonoses

- **Anthrax (*Bacillus anthracis*):** transmitted through contact with infected animals or contaminated animal products (WHO, 2020)

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- Brucellosis (*Brucella spp.*): transmitted through contact with infected animals or contaminated animal products (CDC, 2020)
- Leptospirosis (*Leptospira spp.*): transmitted through contact with contaminated water or soil (WHO, 2020)
- Lyme disease (*Borrelia burgdorferi*): transmitted through the bite of an infected tick (CDC, 2020)

Viral Zoonoses

- Rabies (Rabies virus): transmitted through the bite of an infected animal (WHO, 2020)
- Ebola (Ebola virus): transmitted through contact with infected bodily fluids (WHO, 2020)
- Lassa fever (Lassa virus): transmitted through contact with infected rodents or contaminated surfaces (WHO, 2020)
- Avian influenza (Influenza A virus): transmitted through contact with infected birds or contaminated surfaces (WHO, 2020)

Parasitic Zoonoses

- Toxoplasmosis (*Toxoplasma gondii*): transmitted through contact with infected cats or contaminated food and water (CDC, 2020)
- Echinococcosis (*Echinococcus spp.*): transmitted through contact with infected animals or contaminated food and water (WHO, 2020)
- Taeniasis (*Taenia spp.*): transmitted through consumption of undercooked or raw infected meat (WHO, 2020)

Fungal Zoonoses

- Cryptococcosis (*Cryptococcus spp.*): transmitted through inhalation of fungal spores (CDC, 2020)
- Histoplasmosis (*Histoplasma capsulatum*): transmitted through inhalation of fungal spores (CDC, 2020)

Prion Zoonoses

- Bovine spongiform encephalopathy (BSE) (Prion protein): transmitted through consumption of infected animal products (WHO, 2020)

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2.3 Based on Reservoir Host

1. Anthroponoses – Transmitted from animals to humans (e.g., rabies).
2. Zooanthroponoses – Transmitted from humans to animals (e.g., diphtheria).
3. Amphixenoses – Transmitted in both directions between humans and animals (e.g., salmonellosis) (WHO, 2025; CDC, 2024)

3. TRANSMISSION DYNAMICS OF ZOONOTIC DISEASES

Understanding transmission pathways is crucial for targeted disease surveillance, prevention, and control (Loh *et al.*, 2015).

Direct Transmission

- Contact with Infected Animals – Through bites, scratches, or body fluids like blood, saliva, and urine (Loh *et al.*, 2015).
- Cyclozoonoses – Diseases requiring multiple vertebrate hosts but no invertebrate host (e.g., echinococcosis).

Indirect Transmission

- Vector-Borne Transmission – Spread by mosquitoes, ticks, fleas, or sandflies (Otranto *et al.*, 2009). Example: Lyme disease (Richter *et al.*, 2000).
- Metazoonoses – Diseases transmitted biologically via invertebrate vectors (e.g., plague).
- Saprozoonoses – Require a non-animal developmental site like soil or plants (e.g., cryptosporidiosis).
- Environmental Contamination – Transmission through contaminated water, soil, or food sources (Rees *et al.*, 2021).

Vector-Borne Transmission

Vector-borne transmission occurs when humans are bitten by infected vectors, such as mosquitoes, ticks, or fleas. Examples of zoonotic diseases transmitted through vector-borne transmission include malaria which is

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transmitted through the bite of an infected mosquito (WHO, 2020), lyme disease transmitted through the bite of an infected tick (CDC, 2020) and plague transmitted through the bite of an infected flea (WHO, 2020)

Airborne Transmission

Airborne transmission occurs when humans inhale contaminated air or particles. Examples of zoonotic diseases transmitted through airborne transmission include avian influenza which is transmitted through inhalation of contaminated air and particles (WHO, 2020) and hantavirus transmitted through inhalation of contaminated air and particles (CDC, 2020)

Waterborne Transmission

Waterborne transmission occurs when humans come into contact with contaminated water. Examples of zoonotic diseases transmitted through waterborne transmission include leptospirosis which is transmitted through contact with contaminated water and soil (WHO, 2020)

Some factors influencing transmission dynamics the type of animal host, environmental factors such as climate, temperature, humidity, and other environmental factors that influence the survival and transmission of pathogens (WHO, 2020). Human behavior such as animal handling, food preparation and hygiene practices can influence the risk of transmission (WHO, 2020). Understanding the transmission dynamics of zoonotic diseases is therefore crucial for developing effective prevention and control strategies.

4. CONTROL OF ZOONOTIC DISEASES: THE ONE HEALTH APPROACH

Zoonotic diseases pose a significant public health threat in Nigeria, requiring effective control measures to prevent and mitigate outbreaks. One Health Adopting a One Health approach that integrates human, animal, and environmental health can improve the prevention and control of zoonotic diseases (WHO, 2020).

The One Health (OH) approach is a collaborative, multisectoral, coordinated, and transdisciplinary framework that operates across local, regional, national, and global levels. Its goal is to achieve optimal health

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outcomes by recognizing the interconnectedness of people, animals, plants, and their shared environment (One Health Basic Fact Sheet 2019). With population growth, industrialization, and geopolitical issues accelerating global changes, biodiversity, ecosystems, and migratory movements of both humans and species are increasingly disrupted. Rapid climate and environmental shifts have led to the emergence and reemergence of both infectious and non-infectious diseases.

4.1 Nigeria's One Health Strategy

To address these health challenges, manage epidemic outbreaks, and create synergy among related ministries, Nigeria became the first country in Africa to launch a "One Health plan." This initiative, signed by the ministers of Health, Agriculture, and Environment (Reliefweb, 2019), aimed to strengthen multi-sectoral collaboration for health security. The plan includes the establishment of a full-fledged One Health Programme led by the Nigeria Centre for Disease Control (NCDC). This initiative builds on previous strategies, such as the Nigeria Field Epidemiology and Laboratory Training Programme (NFELTP), which was initiated in 2008 (Ayobami *et al.*, 2021). While NFELTP combined efforts from medical professionals, veterinarians, and laboratory scientists to respond to infectious diseases, it did not initially involve the environmental sector (Ayobami *et al.*, 2021). The current One Health strategic plan, however, has expanded the scope to include professionals from ecology, anthropology, health economics, policy, and artificial intelligence, reflecting a more holistic and collaborative approach to disease control (Ayobami *et al.*, 2021; Achi *et al.*, 2021).

4.2 Current State of Zoonotic Disease Control in Nigeria

Nigeria has also made significant progress in controlling zoonotic diseases, with the establishment of various institutions and programs aimed at preventing and responding to outbreaks. These include:

- National Veterinary Research Institute (NVRI): responsible for conducting research on animal diseases, including zoonotic diseases (NVRI, 2020).

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- National Centre for Disease Control (NCDC): responsible for coordinating the response to public health emergencies, including zoonotic disease outbreaks (NCDC, 2020).
- Federal Ministry of Agriculture and Rural Development (FMARD): responsible for implementing policies and programs aimed at preventing and controlling animal diseases, including zoonotic diseases (FMARD, 2020).

4.3 Further Strategies for Controlling Zoonotic Diseases in Nigeria

- Vaccination: vaccination of animals against zoonotic diseases, such as rabies and avian influenza (WHO, 2020).
- Surveillance: surveillance of animal and human populations for zoonotic diseases, including monitoring of disease outbreaks and reporting of cases (OIE, 2020).
- Public awareness and education*: public awareness and education campaigns to inform communities about the risks and prevention of zoonotic diseases (NCDC, 2020).\
- Intersectoral collaboration: collaboration between human and animal health sectors to ensure a coordinated response to zoonotic disease outbreaks (WHO, 2020).

5. CHALLENGES AND OPPORTUNITIES OF ONE HEALTH APPROACH IN NIGERIA

Challenges Associated with One Health Approach

Several challenges hinder the full application of the One Health approach and other strategies in Nigeria. These include:

1. Lack of Awareness: Farmers and livestock owners are often unaware of the appropriate use of medicines for treating crops and animals. Animals, which serve as companions, food sources, or work partners, can be sources of Multi-Drug Resistant (MDR) pathogens. This calls for better education on the regulation of antibiotic use in animals and the enforcement of good hygiene practices to curb the spread of MDR bacteria and zoonotic diseases (Akinsuyi *et al.*, 2021).

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2. Inadequate Health Security in Slaughter houses: The drive for quick financial gains within the agro-veterinary industry undermines the enforcement of ethical standards in veterinary practices. This includes poor health security practices in slaughterhouses, which contributes to the spread of zoonotic diseases (Akinsuyi *et al.*, 2021).
3. Evolving Ethical Dilemmas: The growing bond between humans and animals has led to new ethical challenges for veterinarians, particularly in the realm of pet care (NCDC, 2025).
4. Implementation Gaps: The Nigerian One Health Strategic Plan (2019-2023) has faced difficulties in implementation due to inadequate monitoring. There are gaps in surveillance, information sharing, and mechanisms for responding to zoonotic and food-borne diseases, as well as antimicrobial resistance (AMR). These gaps hinder effective preparedness and response, and the lack of evidence-based data weakens advocacy for strengthening health systems.
5. Insufficient Workforce Capacity: There is a lack of knowledge and capacity at the subnational and community levels, which impedes the use of quadripartite tools, cohesive preparedness, and engagement with target populations.
6. Despite the progress made, several challenges hinder the effective control of zoonotic diseases in Nigeria, including:
7. Limited resources: Inadequate funding, personnel, and infrastructure hinder the ability of institutions to effectively prevent and respond to zoonotic disease outbreaks (Kamani *et al.*, 2015).
8. Poor disease surveillance: inadequate disease surveillance systems make it difficult to detect and respond to outbreaks in a timely manner (OIE, 2020).
9. Climate change: climate change increases the risk of zoonotic disease emergence and spread, particularly in areas with poor infrastructure and limited resources (IPCC, 2014).

5.1 Opportunities Provided by One Health Approach

Despite these challenges, the One Health approach offers significant benefits:

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1. Prevention of Zoonotic Disease Outbreaks: One Health helps prevent the spread of zoonotic diseases between animals and humans.
2. Reduction of Antimicrobial Resistance (AMR): The approach can reduce the prevalence of AMR infections, improving health outcomes for both humans and animals.
3. Enhanced Information Sharing: One Health promotes improved disease detection, diagnosis, education, and research across sectors.
4. Biodiversity Conservation: It helps in the protection of biodiversity, essential for maintaining ecosystem balance.
5. Improved Food Safety and Security: It supports better practices in food safety, ensuring secure and safe food production.
6. Global Health Security: One Health strengthens global health security by addressing cross-border health issues.
7. Approach to Unmet Treatment Needs: It fosters innovative approaches to treatment, especially in areas where medical needs are currently unmet.

6. FUTURE DIRECTIONS FOR RESEARCH, CONTROL STRATEGIES AND POLICIES

To strengthen zoonotic disease control in Nigeria, the following actions have been recommended:

1. Public Awareness Campaigns: Increase public awareness through mass media and health education campaigns about zoonotic diseases and the importance of One Health.
2. Enhance One Health Collaboration: Foster greater collaboration among medical, veterinary, and environmental professionals to address the complex nature of zoonotic diseases.
3. Regulate Antibiotic Use: Strengthen policies regulating the use of antibiotics in animals to combat the rise of MDR pathogens.
4. Expand Disease Surveillance: Develop and implement improved disease surveillance and rapid response systems across all sectors.
5. Invest in Research: Invest in research to develop novel treatments and preventive strategies for zoonotic diseases and AMR (Okello *et al.*, 2014).

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6. Strengthen disease surveillance systems: improve the capacity of disease surveillance systems to detect and respond to outbreaks in a timely manner (OIE, 2020).
7. Increase public awareness and education: increase public awareness and education on zoonotic diseases to empower communities to prevent and respond to outbreaks (NCDC, 2020).
8. Enhance intersectoral collaboration: enhance collaboration between human and animal health sectors to ensure a coordinated response to zoonotic disease outbreaks (WHO, 2020).
9. Increase funding and resources: Increase funding and resources to support the prevention and control of zoonotic diseases (Kamani *et al.*, 2015).
10. Develop a national zoonotic disease control strategy: develop a national strategy that integrates human, animal, and environmental health to prevent and control zoonotic diseases.
11. Strengthen disease surveillance systems: strengthen disease surveillance systems to improve the detection and response to zoonotic disease outbreaks.
12. Leverage technology: leverage technology to improve the detection and response to zoonotic disease outbreaks.

Research Directions

- Epidemiological studies: conduct epidemiological studies to understand the transmission dynamics, risk factors, and burden of zoonotic diseases in Nigeria (Kamani *et al.*, 2015).
- Vaccine development: develop effective vaccines against zoonotic diseases, such as rabies, Lassa fever, and avian influenza (WHO, 2020).
- Diagnostics: develop rapid, sensitive, and specific diagnostic tests for zoonotic diseases to improve detection and response to outbreaks (OIE, 2020).
- Conducting research on One Health approach: conduct research on the One Health approach, integrating human, animal, and environmental health to prevent and control zoonotic diseases (WHO, 2020).

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Policy Directions

- National zoonotic disease control policy: develop a national policy on zoonotic disease control, integrating human, animal, and environmental health (WHO, 2020).
- Legislation and regulation: enact legislation and regulations to prevent and control zoonotic diseases, including laws on animal vaccination and movement (OIE, 2020).
- Funding and resource allocation: allocate sufficient funds and resources to support zoonotic disease control activities, including research, surveillance, and vaccination programs (Kamani *et al.*, 2015).
- International collaboration: collaborate with international organizations, such as the World Health Organization (WHO) and the World Organisation for Animal Health (OIE), to share knowledge, expertise, and resources on zoonotic disease control (WHO, 2020).

CONCLUSION

Zoonotic diseases pose a significant public health threat in Nigeria, requiring a comprehensive approach to prevention and control. These include requiring continuous research, effective control strategies and policies to prevent and control outbreaks. Addressing the challenges and opportunities of zoonotic diseases in Nigeria requires a multi-faceted approach that integrates human, animal, and environmental health.

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